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FINAL REPORT SISKIYOU DEER-MOUNTAIN LION STUDY (2015-2020)

HEIKO U. WITTMER¹, BOGDAN CRISTESCU², DEREK B. SPITZ², ANNA NISI² &
CHRISTOPHER C. WILMERS²

¹ School of Biological Sciences, Victoria University of Wellington, PO Box 600,
Wellington, 6140 New Zealand (heiko.wittmer@vuw.ac.nz)

² Environmental Studies Department, 1156 High Street, University of California, Santa
Cruz, California 95064, USA



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FINAL REPORT SISKIYOU DEER-MOUNTAIN LION STUDY (2015-2020)

INTRODUCTION

Mule (*Odocoileus hemionus*) and black-tailed deer (*O. h. columbianus*) have long experienced pronounced population fluctuations across their distribution in western North America inclusive of California (Leopold et al. 1947). The underlying mechanisms for the observed short and long-term fluctuations are complex and remain inadequately understood (e.g., Ballard et al. 2001, Pierce et al. 2012, Forrester & Wittmer 2013, Monteith et al. 2014). At high population densities, mule and black-tailed deer appear mostly limited by forage availability and weather with the effect of predation considered largely compensatory (Laundre et al. 2006, Hurley et al. 2011, Pierce et al. 2012). However, compared to many other ungulates, mule and black-tailed deer experience lower and more variable survival of fawns particularly over the initial 6-months period following births (Gaillard et al. 2000, Forrester & Wittmer 2013). The most commonly reported cause of fawn mortality across their ranges is predation from a diverse guild of mammalian predators including black bears (*Ursus americanus*), coyotes (*Canis latrans*), and mountain lions (*Puma concolor*). Relatively high fecundity rates typical of *Odocoileus* apparently enable them to compensate for low fawn survival over longer time frames (Forrester & Wittmer 2013). Recent observations of high predation on both fawns and adult deer, particularly, but not exclusively, in systems that have experienced pronounced changes in predator or alternative prey populations (e.g., Robinson et al. 2002, Cooley et al. 2008, Marescot et al. 2015), have reignited interest in understanding the overall impact of top-down versus bottom-up effects on deer population dynamics.

Two recent changes to our understanding of how direct and indirect interactions between two predator species as well as between predator and their prey species may affect deer populations warrant further investigation. First, black bears have long been known to be an important predator of juvenile cervids including mule and black-tailed deer (e.g., Griffen et al. 2011, Forrester & Wittmer 2019). Recent research, however, has also shown how effective black bears are at usurping deer killed by mountain lions (i.e., kleptoparasitism; Allen et al. 2015a, Elbroch et al. 2015), the primary predator of adult deer across much of their range. For example, in the Mendocino National Forest in northern California, black bears detected 77.2% of deer killed by mountain lions that researchers monitored with cameras (Elbroch et al. 2015) causing the rapid displacement of mountain lions from the majority of these kills. The resulting energetic costs associated with lost feeding opportunities (Elbroch et al. 2014) apparently forced mountain lions to kill adult black-tailed deer, the only ungulate prey species in the system, at rates higher than those observed across the mountain lion's range (Cristescu et al. 2020, Allen et al. 2021). The combined effect of high predation of fawns including from black bears (Forrester & Wittmer 2019) and high predation rates on adult deer from mountain lions (Marescot et al. 2015, Allen et al. 2015b) resulted in a rapid, short-term decline (population growth rate (λ) based on vital rates estimated from a 5-year monitoring study = 0.82) of the local black-tailed deer population (Marescot et al. 2015). Note though that black-tailed deer in the Mendocino National Forest occurred at high densities on summer range at the time of the observed decline (Lounsberry et al. 2015).

Second, the recovery of some apex carnivores such as wolves (*Canis lupus*) in the western United States not only adds another predator of deer in some ecosystems but further increases the complexity of predator-prey interactions through potential direct and indirect effects on subordinate competitors of wolves including mountain lions (Elbroch et al. 2020). Understanding the effect of complex predator interactions, including those mentioned above, on prey populations requires research projects that simultaneously monitor both predators and their prey (e.g., Pierce et al. 2012, Marescot et al. 2015).

Mule and black-tailed deer are the most widespread and abundant ungulates in the State of California, providing recreational opportunities including hunting. The public has raised concerns about the apparent decline of deer populations in several areas of the State (e.g., Siskiyou and Mendocino counties) as well as the lack of research aimed at understanding the underlying causes for the decline. This provided the impetus for developing and funding a range of research and monitoring projects aimed at providing the California Department of Fish and Wildlife (CDFW) with current data needed to inform deer management decisions. Studies aimed at understanding the underlying causes for fluctuations or possible directional changes in deer populations rely on detailed multi-year studies of telemetered individuals. Such studies provide information including age-specific vital rates, causes of mortality, and their combined effect on deer population growth. They can also help understand movement patterns and resulting population structure and help quantify the link between habitat use and selection and overall population performance. Studies of telemetered deer in California are currently being expanded to be representative of the diversity of ecosystems in the State, and continued data collection is crucial for developing and updating effective deer management and conservation plans (e.g., Pierce et al. 2012, Monteith et al. 2014, Forrester et al. 2015, Marescot et al. 2015, Bose et al. 2017, 2018).

In northern California's CDFW Region 1, declining hunter harvests of deer, apparent deer population declines, and a lack of information about factors affecting deer populations have long generated considerable interest from the public and resource management agencies. In 2010, the Siskiyou County Board of Supervisors thus passed a resolution to actively encourage, develop, and help implement cooperative strategies and projects geared toward research, restoration, and sustainability of abundant, healthy deer conservation units in the Region. The Siskiyou Deer-Mountain Lion Study, a collaboration between the CDFW and the University of California Santa Cruz (UCSC), is ultimately an outcome of this resolution. Deer captures for the project started in 2015 with UCSC researchers taking over study responsibilities upon execution of the contract agreement on 15 June 2016 (Agreement Number P1580031). The Siskiyou Deer-Mountain Lion Study had the following specific objectives:

1. Identify specific study area(s) and study sites in agreement with the California Department of Fish & Wildlife.
2. Estimate deer population size, composition, and changes in abundance using fecal DNA mark-resight methods.

3. Assess factors influencing deer population growth
 - a) Estimate deer population change within project study sites using matrix modelling approaches that incorporate estimates of annual fawn and adult female survival, and age class-specific pregnancy rates and litter sizes.
 - b) Evaluate the potential effect of conception date on fawn survival and recruitment.
 - c) Investigate the hypothesis that post-season buck ratios influence conception dates.
 - d) Determine the relationship between age and body condition of adult female deer and their productivity.
 - e) Investigate relationships between habitat quality/quantity and productivity of female deer.
 - f) Estimate the occupancy and/or abundance of carnivores including mountain lions, black bears, coyotes, and bobcats within representative sites.
 - g) Determine rates of predation as a function of deer sex and age classes and its potential influence on deer population growth.
 - h) Assess the diets of mountain lions in the study area and their rates of predation on deer.
 - i) Test the hypothesis that competition with other carnivores (e.g., black bears) increases predation rates on deer by mountain lions.

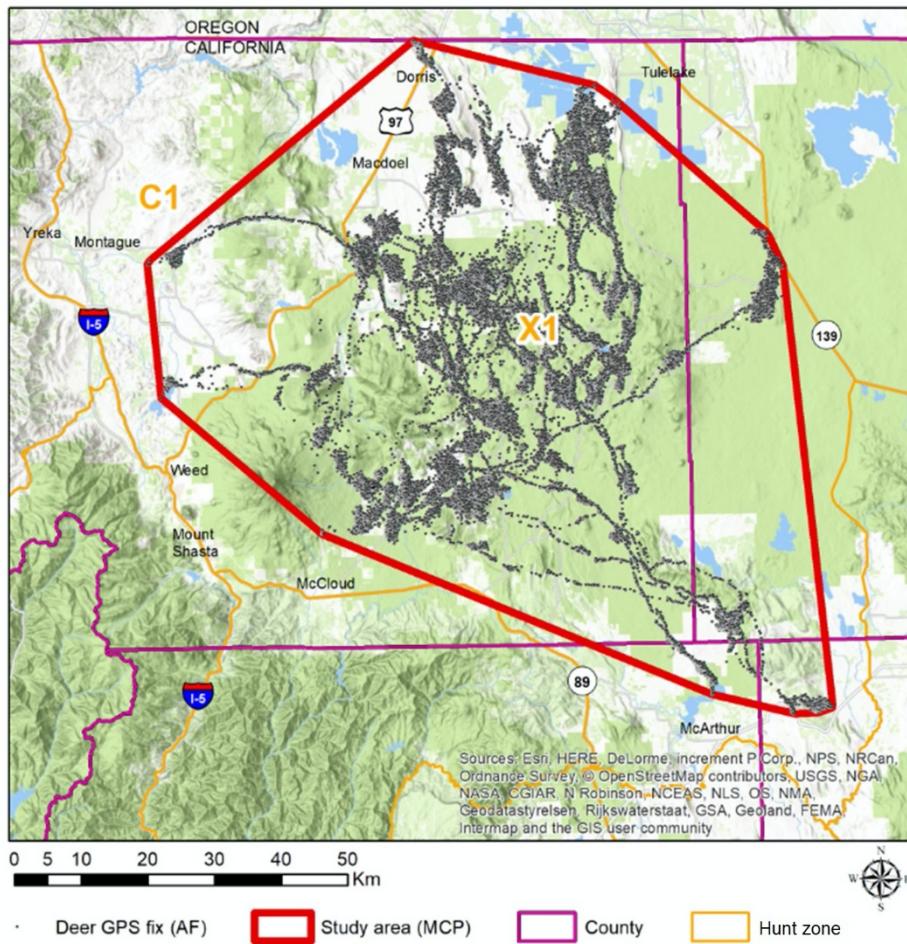
4. General deer ecology
 - a) Identify the diet composition and seasonal changes in foraging strategies of deer.
 - b) Identify and describe characteristics of core reproductive areas, migration corridors, and winter ranges of radio-collared deer.

This report summarizes current outcomes of the study using data collected over the time period from March 2015 until the end of fieldwork in June 2020.

STUDY AREA

The study area is located in northern California. The area primarily falls within the X1 and C1 hunting zones and was selected by the CDFW. The study area is likely part of

an introgression zone between black-tailed deer primarily to the west and mule deer primarily to the east and from here onwards we will refer to them simply as “deer”. We defined overall study area boundaries *post-hoc* based-on GPS locations of all collared deer and mountain lions. A minimum convex polygon (MCP) encompassing all deer locations extended over 6,702 km² (Fig. 1A) and covered four counties: Siskiyou, Modoc, Shasta, and Lassen. The corresponding MCP encompassing all mountain lion locations was much larger (15,335 km²) and included areas in southern Oregon to the north and Shasta Lake to the south (Fig. 1B).



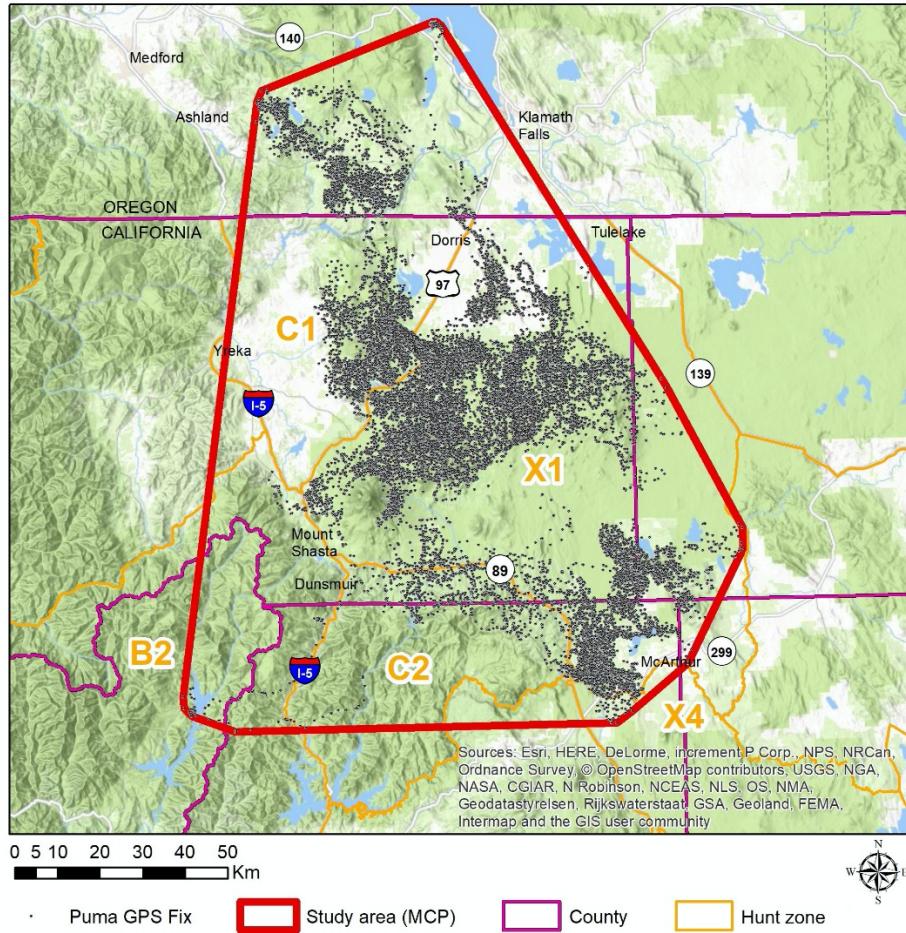


Fig. 1. (A) Siskiyou deer study area as delineated by a minimum convex polygon (MCP) based on GPS location data from 81 adult female deer monitored between 2015-2020. (B) Siskiyou mountain lion study area MCP based on GPS location data from 14 mountain lions monitored between 2017-2020.

The terrain and topography of the study area are extremely diverse. The western parts of the study area encompass Mount Shasta (4,322 m/14,179 ft) and thus included the southern end of the Cascade Range. Topography in the southern Cascade Range is dominated by complex and steep terrain. Where topography is less pronounced, remaining cones of extinct volcanoes add terrain complexity. The north-eastern parts of the study area are dominated by plateaus that range in elevation from approximately 1,350-2,000 m or 4,430-6,560 ft. Plateau topography is formed by volcanic activities and included Lava Beds National Monument. Both elevations and topography are less pronounced in southern and north-eastern parts of the study area. The climate in the study area varies locally but is generally characterized by dry and warm summers and cool and, in some places, wet winters. Annual precipitation ranges from approximately 250 mm in the northeast to 1,000 mm in the south around Shasta Lake. Most of the precipitation falls as snow in winter, particularly at higher elevations. Significant snow accumulation on higher peaks including Mount Shasta ensures the gradual release of

moisture well into the dry summers. Nevertheless, surface water often dries up during the hottest months of the year.

Landownership included public (state and federal) and private lands. The majority of the study area fell within 3 National Forests: Shasta-Trinity, Klamath, and Modoc National Forests. Past and current logging operations in these National Forests have resulted in a mosaic of unevenly aged forest stands including large clear-cuts that are sometimes being actively replanted by logging operators. The past logging history is extensively summarized in the *McCloud Flats Deer Plan* (California Department of Fish & Game 1983). Some forest stands are privately owned and operated. Agricultural activities on private lands included limited alfalfa production relying on artificial watering practices and low-intensity livestock production, particularly cattle. Several major highways dissected the study area. Notable were I-5 and HWY 97 to the west and north-west, and HWY 89 to the south. Train tracks following a north to south direction were also dissecting the study area. The National Forests are serviced by a network of well-maintained forest roads, both paved and unpaved. However, with the exception of traffic associated with logging operations, traffic on these forest roads was almost exclusively limited to tourism in the summer months and the fall hunting season. Only a few, small settlements can be found within and in the vicinity of the study area, the largest being the town of Mount Shasta with approximately 3,300 inhabitants.

The study area encompasses several Level IV ecoregions including (from west to east): Shasta Valley, High Southern Cascades Montane Forest, Low Southern Cascades Mixed Conifer Forest, Modoc Lava Flows and Buttes, California Cascades Eastside Conifer Forest, and Pit River Valleys (Environmental Protection Agency 2012). Despite much of the soils consisting of weathered volcanic rocks with limited suitability for agriculture, the varied terrain and localized climate and soil moisture levels result in a very diverse plant community, particularly of shrubs. Based on the CALVEG landcover type classification, eastern ranges are predominantly juniper (*Juniperus* spp.) and sagebrush (*Artemisia* spp.), with juniper also widespread in the west. Across the remainder of the study area, lower elevations are dominated by bitterbrush (*Purshia tridentata*) in the north, ponderosa pine (*Pinus ponderosa*), and mixed shrub and conifers in the south and west. Higher elevations supported mixed montane shrubs, mixed conifer, and fir (*Abies* spp.) forests.

Deer are the most abundant and widespread native ungulate across the study area. Other native ungulates include elk (*Cervus canadensis*) and, localized, pronghorn (*Antilocapra americana*). Cattle were grazed on both public and private lands and some feral horses were present in the central north-eastern part of the X1 deer hunt zone. Mountain lions, black bears, coyotes, and bobcat (*Lynx rufus*) were present at presumably varying densities across the study area. One wolf pair was known to be present and reproduce in the study area at the onset of the project in 2015 but failed to establish a permanent population and wolves were considered functionally absent between 2016 and 2020.

METHODS

STUDY SITES

Based on historical information, we expected deer in the study area to be migratory (California Department of Fish & Game 1983). We used input from CDFW and GPS location data from collared adult female deer to help select initial study sites within the study area. Specifically, we used initial GPS location data for female deer captured in the winter of 2015 by the CDFW (see adult deer captures below) to scout and subsequently select suitable sites for capturing deer fawns on summer ranges in 2016. We then coordinated with the CDFW and continued adult deer captures on both summer and winter ranges in subsequent years and used all available deer location data until 2017 (i.e., GPS location data from adult females, VHF location data from fawns) to identify and delineate potential deer winter ranges. These ranges should not be considered distinct (i.e., deer are likely continuously distributed across the landscape albeit at varying densities) as they are necessarily only a representation of areas used by our sample of deer rather than the deer population *per se*. Also, the primary purpose of delineating these potential summer and winter ranges was to develop and conduct vegetation surveys over an area we also attempted to estimate deer densities for (see deer population density below) and thus allow us to assess the importance of bottom-up (i.e., forage related) impacts on deer.

FAWN CAPTURES & MONITORING

We conducted fawn captures under a scientific collection permit issued by the California Department of Fish & Wildlife (SC10859). All fawn capture and handling procedures were further approved by an Institutional Animal Care and Use Committee at the University of California, Santa Cruz (protocols Wilmc1509 & Wilmc1811) and adhered to guidelines established by the American Society of Mammalogists (Sikes et al. 2016).

We captured fawns from June 16th onwards during our 2016 pilot study immediately after the contract had been executed ($n = 4$). Between 2017 and 2019, we captured fawns from June 1st onwards until early July ($n = 141$) using 3 different methods. First, we drove along forest roads and used handheld spotlights on both sides of the vehicle to locate fawns during the night. Second, we opportunistically captured fawns we encountered while driving during daylight hours. Finally, we scanned meadows and forest habitats during both day (binoculars) and night (spotlights) for post-parturition females and walked in to locate nearby hidden fawns if we deemed doe behavior suspicious (e.g., hesitation or unwillingness to move away despite being approached, frequent scanning of the same location). We captured fawns either by hand or with handheld nets, and sometimes after a brief chase. Capture personnel wore new latex gloves for each capture to minimize scent contamination. Once captured, we transferred fawns into pillowcases where they could be more easily handled. Handling of fawns included recording their sex, weight, and then fitting all individuals with small colored and numbered plastic ID ear tags. We also recorded the state and dryness of the umbilical cord and measured hoof growth lines with calipers (Sams et al. 1996) to

estimate the approximate fawn age at capture. Finally, we attached very high frequency (VHF) motion-sensitive radio collars (Vectronic Aerospace, Germany) with expandable neckbands that were purpose-designed for fawns. Collars were programmed to switch to a mortality signal if they remained stationary for > 4 hours. Based on factory programming (VHF signals were active from 6 am until 10 pm), we estimated that batteries should last for up to 2 years. Based on 129 captures for which processing times were recorded, capture processing ranged from 5 - 20 minutes and averaged approximately 11 minutes. Once collared, fawns were released at their capture sites. We limited handling procedures for fawns that struggled or vocalized excessively to only attaching the VHF collar. This was to avoid capture related injuries, to minimize stress, and to reduce the likelihood of drawing in potential predators of fawns. Note that we returned to the capture location over the following 24 hours to install a remote camera (see information on predator monitoring below).

We monitored the status of fawns (survival and general location) daily from capture until early September using ground-based telemetry. We reduced monitoring efforts to 1-4 times per month until fawns turned 1 year old in June the following year. Such changes in monitoring frequency are common (e.g., Marescot et al. 2015) as daily monitoring is thought to facilitate the assessment of causes of mortality when fawns are small.

YEARLING DEER MONITORING

No 1-year-old deer (yearlings) were captured and collared during the study. However, the approximately 2-year initial battery life expectancy of fawn collars allowed us to continue monitoring surviving fawns as yearlings and until they transitioned into the adult age class on their second birthday. Small batteries powering fawn collars reduced the range of their VHF signal making ground-based relocation efforts challenging. Nevertheless, monitoring of yearlings was attempted at least once per month.

ADULT DEER CAPTURES, MONITORING, AND MOVEMENT STRATEGIES

All captures of adult female deer \geq 2-years-old were the responsibility of the CDFW and followed an internally approved capture plan. Captures were initially conducted by helicopter using netguns in March 2015 ($n = 25$). All captured deer in 2015 were flown to a central processing site where they were restrained with leg hobbles. At the processing site, deer were weighed and provisionally aged based on tooth wear and eruption patterns. Twenty-one deer were administered lidocaine (0.5 cc of a 2% solution) prior to also having a tooth extracted for age determination using cementum annuli methods but all samples that year were retained by CDFW staff and unfortunately were lost prior to submission to the contracted lab for processing. Blood samples were taken including to test for pregnancy based on progesterone levels and an ultrasound was used to confirm pregnancy and record the number of fetuses in uteri. Deer received a number of prophylactic treatments at varying doses including Penicillin (3-4 cc), Cloxacillin (1 cc), Vital E (3-5 cc), and MuSe (1 cc), all administered subcutaneously. Finally, the body conditions of all deer were assessed at up to four body parts. Assigned body condition scores (BCS) ranged from 1 (very poor) to 5

(excellent) and increased in 0.5 increments. We report BCS assessed at the base of the tail (preferred) or the pelvis (if no value was recorded for the base of the tail) as these were likely most closely aligned with scores assigned at deer captures in subsequent years (see below). All deer then received an individually numbered ear tag ID and most were fitted with two collars. The first collar, a GPS “lifetime” collar (Survey Globalstar, Vectronic Aerospace, Germany) with satlink and VHF capabilities, recorded locations once every 2 weeks and was intended to remain on the animal for its remaining life. A second, satellite-enabled GPS collar (Vertex Plus Iridium, Vectronic Aerospace, Germany) recorded locations every 1 hour and was programmed to automatically drop off after 1 year. GPS collars were also programmed to send mortality notices via satellite if a collar remained stationary for > 4 hours. Combined, collar weights were below 3% of body weights of adult deer. Deer were either released at the processing site or returned to the vicinity of their original capture locations.

In subsequent years, adult female deer were searched for by driving along forest roads and captured using a tranquilizer dart delivered with a dart gun from the vehicle and sometimes after stepping outside the vehicle for a brief stalk. This allowed for a more targeted collaring of adult deer in areas where we also captured fawns (see above). Captures occurred in July-August of 2016 (n = 17), August-September 2017 (n = 11 including 2 recaptures of previously collared individuals), and both March (n = 16) and August-September (n = 19) of 2018. Deer were anesthetized using a Telazol/Xylazine combination. Teeth samples were collected for age determination using cement-annuli methods (Matson’s Laboratory LLC, Missoula, MT, USA) during 17 captures in 2016 and 33 captures in 2018. An ultrasound was used for females captured in March 2018 to determine the number of fetuses *in uteri*. Body condition assessments slightly differed from those in 2015. Specifically, assessment was based on a modified rump fat body condition score (rBCS) that ranges from 1 (very poor) to 5 (excellent) (Gerhart et al. 1996, Cook et al. 2010) which is the more commonly used BCS in CDFW deer research projects. Other handling procedures followed those described above. All deer were fitted with one Vertex Plus Iridium GPS collar programmed to drop off after 1-1.8 years, except deer captured in March 2018 that were fitted with one Survey Globalstar GPS collar. Vertex collars were programmed to record locations every 1 hour (2016 captures) or every 2 hours (2017 and 2018 captures). Survey collars were programmed to acquire one location every 13 hours, which was the most intensive fix rate possible with this collar model. All deer were reversed using Tolazoline and released at their capture location.

Note that Survey Globalstar GPS collars functioned for much shorter time periods than anticipated. However, the associated VHF transmitters in these collars allowed us to continue monitoring the status of adult female deer once every month using ground-based monitoring described for fawns and yearlings above.

We quantified movement strategies of GPS collared deer based on net squared displacement (the square of the distance between the starting point and each subsequent point; NSD) of individual deer tracks using the R package MigrateR 1.1.0 (Spitz et al. 2017). We fitted the NSD of each yearly track to models representing 1)

residency, 2) nomadism, 3) dispersal, 4) migration, 5) mixed migration, and 6) multi-range migration (Spitz et al. unpublished manuscript). We compared the fit of these models to the NSD of each track using Akaike Information Criterion (AIC; Burnham & Anderson 2002) and selected the best supported movement classification for each deer. This approach allowed us to determine migration distances between summer (fawning) and winter ranges. Furthermore, it allowed us to visualize potentially important movement routes and thus identify possible interactions of collared deer with highways in the study area.

DEER CAUSE OF MORTALITY ASSESSMENTS

Once UCSC personnel assumed responsibilities for monitoring both fawns and adult deer from June 2016 onwards, causes of mortalities were investigated and assigned based on a purpose developed assessment method. A detailed protocol describing our methods will be submitted for peer-review to a scientific journal. The protocol describes the field assessment, all evidence collected at the mortality site, and how evidence was used to determine the cause of mortality. Our framework also describes a practical method for assigning a confidence level (low, medium, high) to cause of mortality assessments in the field. We report causes of mortality in this report including levels of confidence but refer to Cristescu et al. (unpublished manuscript) for further details regarding our methodology.

DEER VITAL RATES

Data collected during captures and the subsequent monitoring of collared individuals allowed us to estimate the following vital rates for deer.

- a) *Pregnancy rates:* Estimated from data collected for 25 females captured in March 2015 and 16 females captured in March 2018 (yes or no). Annual pregnancy rates are derived by dividing the total number of individuals confirmed pregnant in a given year by the total number of females assessed the same year. From these annual values we then determined the mean annual pregnancy rate for our deer sample.
- b) *Number fetuses per pregnant female:* Estimated from ultrasound data collected for pregnant adult females captured in March 2015 ($n = 24$) and March 2018 ($n = 15$). From these annual values we determined the mean number of fetuses/female for our deer sample.
- c) *Fawn survival:* We estimated monthly fawn survival from the monitoring history of telemetered individuals using a staggered-entry design for the Kaplan-Meier estimator (Pollock et al. 1989). All fawns entered the survival analysis in the months they were captured. We censored individuals in the month when we no longer were able to confirm their status. We used the estimated date of mortality from our detailed mortality site investigations to allocate a month to all fawns we confirmed to have died during the study. We then converted monthly survival estimates into yearly survival estimates and estimated the overall mean annual survival rate of fawns ($\pm SE$) from these yearly

estimates. We did not estimate survival rates of female and male fawns separately as our annual sample sizes were not large enough.

d) Yearling survival: We estimated the survival rate of yearlings from the monitoring history of telemetered individuals using a staggered-entry design for the Kaplan-Meier estimator (Pollock et al. 1989) as outlined for fawns above. However, due to low yearly sample sizes, we pooled the monitoring histories of all individuals (females and males) across all years into one monitoring period with 12 monthly intervals. Even with pooling, the average number of yearlings monitored per month was only 11.58 (± 8.11 SD) with monthly sample sizes particularly low from December onwards due to issues associated with battery life of collars and difficulties tracking movements particularly those of dispersing male yearlings. While pooling was necessary due to low sample sizes, it may have resulted in slightly biased (i.e., low) survival estimates for female yearlings due to the likely elevated risk of mortality of male yearlings during dispersal.

e) Adult female survival: We estimated the survival rate of adult females ≥ 2 -years-old as outlined for fawns above as we deemed average monthly sample sizes of collared adult females of 26.33 (± 10.53 SD) females/month large enough to result in unbiased estimates. Due to the limited information collected on age of our sample of collared adult females, we did not attempt to investigate possible reduced survival of senescent individuals.

DEER POPULATION GROWTH

We used a post-breeding Lefkovitch projection matrix (Caswell 2001) to estimate the population growth rate (λ). As mule and black-tailed deer are polygynous, we built a female only matrix with 3 stages: fawns, yearling, and adults. We assumed deer to first reproduce as 2-year-olds (Monteith et al. 2014). As none of the females assessed for pregnancy in our study were classified as yearlings, we used pregnancy rates for mule deer provided in Monteith et al. (2014) to adjust our data collected for adult females accordingly. Specifically, data in Monteith et al. (2014) suggested that the pregnancy rate of a sample of 22 yearlings was 69.4% of the pregnancy rate of a sample of 803 adult females (i.e., 0.68 versus 0.98). We also adjusted the number of fetuses to reflect a 50:50 sex ratio at birth. Combined, these adjustments allowed us to calculate stage-specific reproductive rates (r) as the product of pregnancy rates, mean number of fetuses, fawn sex ratio, and stage-specific survival. In the absence of precise age estimates based on cementum annuli for all collared females and resulting small sample sizes, we refrained from adding a “senescent” stage to our projection matrix despite research in deer and other ungulates showing declines in both survival and reproductive rates with increasing age (Gaillard et al. 2000, Marescot et al. 2015). Our estimates of λ may thus be slightly biased high. Using our vital rate estimates, we parameterized the following matrix

$$L = \begin{bmatrix} 0 & r_y & r_a \\ \phi_f & 0 & 0 \\ 0 & \phi_y & \phi_a \end{bmatrix},$$

where ϕ denotes stage-specific survival probabilities for fawns (f), yearlings (y) and adult females (a), and r denotes stage-specific reproductive rates for yearlings (y) and adults (a).

We used a simulation approach to estimate λ and to account for uncertainty in estimates of vital rates. Specifically, we ran 1,000 iterations of our matrix calculations in which age-specific survival probabilities and pregnancy rates were drawn from a beta distribution based on their respective means and standard errors (survival rates) or standard deviations (pregnancy rates). Note that in the absence of actual data, we used the standard deviation derived from pregnancy data of adult females for our adjusted pregnancy rates of yearlings. For each iteration, we also drew the expected number of fetuses per female from a gamma distribution based on the respective parameter mean and standard deviation. We then derived estimates of lambda from the dominant eigenvalues of the 1,000 simulated matrices and determined 95% confidence intervals based on the percentile method. Finally, we conducted sensitivity and elasticity analyses using the *vitalsens* function in the R package *poppbio* (Stubben and Milligan 2007) to understand absolute and relative contributions of underlying vital rates as well as matrix elements to projected deer population growth.

DEER POPULATION DENSITY

a) *Summer*: Starting at the end of July 2017, we established pellet transects on 4 summer (fawning) ranges to estimate deer densities based on DNA capture-mark-recapture methods (Lounsberry et al. 2015). We established 6 transects per fawning area for a total of 24 pellet transects. Including the initial setup, each transect was sampled 6 times with on average 9 days (range = 7-10) between sampling events. Deer pellets were collected until September 2017 following a protocol outlined in Brazeal et al. (2017). In total, we collected 960 pellet samples (4-6 pellets per pellet group encountered), of which 402 were “fresh” and 558 “not fresh” according to pre-established criteria. The samples were stored in ethanol and transferred for DNA extraction to Dr. Ben Sack’s lab at the University of California, Davis. In total, 261 samples (of 520 chosen from the 2017 samples) were successfully genotyped for summer ranges. This resulted in 142 individual deer being identified (average capture rate = 1.84).

b) *Winter*: During January-April 2019, we established a total of 28 pellet transects to estimate deer densities on 8 winter ranges. Transect setup and deer pellet collection followed published protocols described for summer ranges above and each transect was sampled 5 times with on average 9 days (range = 7-12) between sampling events. Pellet collection was completed in mid-April 2019. In total we collected 1,072 pellet samples (4-6 pellets per sample). The samples were again stored in ethanol and transferred to Dr. Ben Sack’s lab at the University of California, Davis, for DNA extraction. In total, 672 samples (of 1072 chosen from the 2019 samples) were successfully genotyped for winter ranges. This resulted in 419 individual deer being identified (average capture rate = 1.60).

In addition to pellet collection, we deployed remote cameras in the same areas as the transects to obtain information on deer age class and relative group size on winter ranges (Furnas et al. 2018). The camera data can be used to refine statistical modelling of pellet-based deer density estimates as it helps understand the age- and sex composition of deer in the vicinity of transects. While cameras were not specifically established on pellet transects on summer ranges, comparable data was collected with cameras deployed at fawn capture locations on the respective ranges (see predator monitoring below).

DNA genotyping data was provided to Dr. Brett Furnas (CDFW) who used a SECR based approach to estimate age- and sex-specific deer densities on both summer and winter ranges in the study area.

DEER DIET

- a) *Summer:* From the end of July until September 2017, we collected deer pellet samples along the 24 pellet transects we established for DNA-based deer density estimation (6 transects in each of our 4 fawning areas). We collected two pellets from each deer pellet group encountered that contained non-degraded/non-partially decomposed pellets. Samples were pooled across transects for each fawning area. We stored samples in dry bags for microhistology analysis of deer diet by a suitable lab.
- b) *Winter:* During January-April 2019, we collected deer pellet samples along the 28 pellet transects we established for DNA-based deer density estimation on 8 winter ranges. We collected two pellets from each deer pellet group encountered that contained non-degraded/non-partially decomposed pellets. Samples were pooled across transects for each sampling area (winter range). We stored samples in dry bags for microhistology analysis of deer diet by a suitable lab.

All deer diet samples were provided to the only remaining lab in the US who still conducts microhistology analyses from pellets, but samples have not been processed at the time of writing. External funding has been secured for the analysis to be completed.

While deer diet estimates from pellets have not yet been processed, we can provide a detailed list of plant species that, combined, contribute significantly to the diet of deer in the study area. The list is based on signs of deer browsing recorded during our intensive vegetation surveys.

DEER FORAGE AVAILABILITY & QUALITY

During July-October 2018, we carried out intensive habitat surveys on summer ranges to estimate deer forage availability. Surveys were designed to quantify plant species composition, percentage cover, and biomass using the line intercept and yield rank

methods (summarized in Higgins et al. 2012). Surveys covered our 4 focal summer (fawning) ranges (Asperin Butte, Buck Mountain, Fons Butte, Red Hill). During February-April 2020, we also carried out intensive habitat surveys on deer winter ranges to estimate forage availability. Surveys occurred on 8 focal winter range areas (Day Bench, Lake Shastina, Montague, Mount Dome, Mount Hebron, Sheep-Mahogany Mountain, Tionesta, and Wildhorse Mountain). Each line intercept was 100 m long and oriented on a random cardinal direction. Any vegetation that came into contact with an intercept pole, or its projection 1.8 m above ground level was considered intercepted. The 1.8 m mark represents the approximate maximum height of deer foraging, limiting sampling efforts to available food. Ferns on both summer and winter ranges, and conifers other than firs on summer ranges were not recorded when encountered due to either no or low expected utilization by deer.

We recorded plant species intercepted at 1 m marks along the transect to the finest taxonomic level possible and measured the plant specimen's length and width. In summer, forbs were identified to species or genus levels, whereas graminoids were classified as grasses, sedges, or rushes. In winter, herbaceous vegetation was pooled as either forb or graminoid because of difficulties in identification due to the dry state of the vegetation. To estimate woody forage biomass available to deer, we laid out 5 x (1 m x 1 m) quadrats at equal intervals along each transect and counted all palatable live twigs of woody plants within the quadrats. Counts included all live palatable annual growth twigs up to 1.8 m high to reflect browse material available to deer. Palatability was determined based on shrub species-specific browse diameters, that we calculated based on measuring the diameter at point of browse for 100-200 twigs from specimens we measured at randomly sampled locations prior to laying out the line intercept transects. To estimate herbaceous forage biomass available to deer, we laid out 10 x (0.25 m x 0.25 m) quadrats at equal intervals along each transect and recorded comparative yield on a point scale. The scale included ranks 1-5 in 0.25 increments, where rank 1 was the lowest yield (no herbaceous biomass) and rank 5 the highest yield (maximum herbaceous biomass). Yield rank recording was limited to herbaceous material found within the quadrate, and its projection 1.8 m above the ground.

We clipped samples from shrub and conifer tree species for nutritional analysis of potential woody plant deer foods. Clippings were made from all woody plants with percent coverage \geq 5% based on our line intercept transect data. Distinct percent cover calculations were made for each summer and winter range polygons. All shrub species clipped contained evidence of browse. Although we did not identify browse on conifer species, we still clipped select conifers due to their perceived potential to be used by deer during severe shrub food shortages (e.g., harsh winters). We clipped shrubs on focal ranges of collared deer, revisiting summer ranges in 2019, and performing clipping after vegetation cover and biomass estimation were completed on winter ranges in 2020. Clipping therefore occurred in the season corresponding to when most of the deer population utilized these areas (i.e., clipping in summer for summer ranges, clipping in winter for winter ranges). Due to logistical constraints, we did not revisit the line intercept transects for clippings, but instead clipped at random locations accessible along the network of Forest Service and logging roads within the delineated summer

and winter range polygons. To reduce potential effects of road edges on vegetation communities, we aimed to collect clippings \geq 50 m from roads. At each site we clipped the palatable annual growth of the most recent year from several individual plant specimens of a given woody species. We combined samples for each species within each range polygon, thereby obtaining a species-specific composite sample as an aggregate of clippings, which provided sufficient biomass for nutritional analyses.

All vegetation samples were sent to Washington State University's Wildlife Habitat and Nutrition Laboratory to estimate a range of nutritional parameters including: % crude protein, gross energy, % in vitro dry matter digestibility (IVDM), % neutral detergent fibre, % acid detergent fibre, % acid insoluble ash, % acid detergent lignin, and tannins. Due to COVID, processing of our samples was delayed with results only becoming available in December 2020.

PREDATOR MONITORING

We monitored the distribution and abundances of known predators of deer in our study area (mountain lions, black bears, coyotes, and bobcats) using remote cameras. Data on predators came from two different camera deployment methods.

a) *Effect of predation on fawn survival:* Predation is the most significant cause of mortality of mule and black-tailed deer fawns across their ranges (Forrester & Wittmer 2013). The vulnerability of fawns to predation likely peaks over their first month following birth (e.g., Forrester & Wittmer 2019) but remains significant over their entire first year of life; predation is responsible for 55% (95% CI = 49-61%) of all reported causes of fawn mortality (Forrester & Wittmer 2013). To enable us to determine if the risk of dying from predation during summer was related to the number of predator species as well as their relative abundances, we monitored predators using remote cameras deployed within 100 m from fawn capture sites. Camera deployment started in 2017, and we set cameras within 24 hours of a fawn's capture. Cameras set at fawn capture sites were intended to provide information at the home range scale (Johnson 1980) of individual fawns.

To maximize detection rates, cameras targeted expected movement paths of predators such as decommissioned logging roads, topographic funneling/pinch points, dry creek beds, and habitat edges and were not baited or lured. Note that we used data from the same camera if the capture locations of 2 or more fawns were less than 100 m apart. Cameras were set to record 3 photos per trigger and remained active for approximately 3-4 months (Table A1). From the photos, we extracted all records of mountain lions, black bears, coyotes and bobcats as well as date and time information. We standardized the data to 24 h intervals (camera trap nights) and discarded the photographs acquired during the days of camera deployment and retrieval. We calculated relative abundance indices for each predator species by dividing the number of photographs of a given predator by the number of camera trap nights a given camera was active.

b) Effect of predation on summer and winter ranges: We also used cameras to determine the detection and relative abundance of predators at the landscape scale (deer summer and winter ranges). Cameras were active for various lengths of time based on field logistics around retrieval, but we aimed to obtain data for 3 continuous months (90 days) of monitoring for each camera station.

Summer ranges: Between May-June and September 2019, we deployed a total of 48 cameras across a 1,728 km² area covering all identified summer ranges and the surrounding landscape. One camera each was placed into a 6 x 6 km (36 km²) grid cell. The size of the grid cells was based on approximate home range estimates for female black bears (e.g., Grenfell & Brody 1986, Koehler & Pierce 2003) and were intended to ensure independence among camera locations. To maximize predator detection, we generated the centroid of each cell and a circle with 1 km radius that was centered on the cell centroid. We used high resolution aerial imagery overlaid with terrain in Google Earth 3D to focus on topographic features within the circle's radius that could encourage or funnel predator movement. We selected 3 possible locations for camera station placement within the circle and entered their coordinates in a hand-held GPS. We visited one location for camera placement and withheld the other 2 locations as back-ups in the event ground conditions were unfavorable (i.e., location was in fresh logging cutblock). We carried out a search within 100 m radius for landscape features that promoted predator movement and placed a camera at the location that likely maximized predator detections (e.g., old roads, funnel areas, or game trails).

Winter ranges: Between November 2019 and April 2020, we deployed a total of 84 cameras across a 3,024 km² area covering all identified winter ranges and a broader area around these. To enable comparison with summer range data, grid cell size was the same for summer and winter ranges and camera deployment procedures were comparable to those described for summer above. Some habitats on winter ranges were more open than on summer ranges, therefore we could not always rely on standing trees to affix the cameras and used metal stakes instead.

MOUNTAIN LION CAPTURES & MONITORING

Mountain lion research was approved through a Memorandum of Understanding between the CDFW and the UCSC. All mountain lion capture and handling procedures were approved by veterinarians with the Wildlife Investigations Laboratory of the CDFW, the UCSC Institutional Animal Care and Use Committee (protocols Wilmc1509 & Wilmc1811), a CDFW Scientific Collection Permit (SC-11968) and adhered to guidelines established by the American Society of Mammologists (Sikes et al. 2016). All mountain lion captures were led by a CDFW & UCSC approved capture supervisor.

We deployed baits and monitored these with satellite transmitters and camera traps. We only set and activated a baited cage trap with a deer carcass if a mountain lion had visited the bait. To alert us of a mountain lion entering the trap, we attached a trap monitor (TT4, Vectronic Aerospace, Germany) to the cage. Using a trap monitor allowed us to reduce the number of times we had to physically check the traps and also to

minimize the time captured mountain lions spent in the trap prior to processing. The capture team waited in the vicinity of the trap so that they could respond rapidly in case of a trap trigger. We darted mountain lions caught in traps using a less powerful Pneu-Dart compression pistol.

We anesthetized captured mountain lions using Telazol (tiletamine and zolazepam) as outlined by the CDFW Departmental Policy on the Use of Pharmaceuticals in Wildlife. We used Telazol at a concentration of 100 mg/ml and administered initial dosages of 2 ml for females and 3 ml for males. We applied Midazolam at a concentration of 5 mg/ml as needed for improved muscle relaxation. Throughout the handling procedures, we monitored vital signs including body temperature and respiration rates. We determined sex of all captured mountain lions and then weighed, measured, and fitted each animal with an individually numbered ear tag ID. Measurements included curvilinear nose-to-rump length, tail length, chest girth, head and neck circumferences, foot pad widths, and several metrics for legs and teeth. We used measurements of gum-line recession to determine the approximate age of captured mountain lions (Laundré et al. 2000). Finally, we fitted each mountain lion with a satellite enabled GPS collar (Vertex Plus, Vectronic Aerospace, Germany) that also collected accelerometer data. Collars could be remotely re-programmed using satlink and UHF technology and were accessorized with automatic and on-demand drop-offs to facilitate recovery of the store-on-board accelerometer and activity data at the end of the collar's lifetime.

Note that all capture data was provided to CDFW and included in a recent meta-analysis aimed at determining optimal capture and immobilization procedures for mountain lions in California (Basto et al. unpublished manuscript).

We programmed GPS collars to acquire locations every 2 h throughout the regular monitoring period and every 5 minutes during intensive monitoring periods for kill rate estimation (see mountain lion diet & kill rates below). We accessed location data through the Vectronic GPS Plus X interface via a UCSC secure server after the collars had uploaded acquired location data via the satellite.

Note that mountain lion GPS location data from our study animals has been made available to CDFW and were used in a state-wide analysis to estimate the amount of suitable habitat for mountain lions across California (Dellinger et al. 2020).

Collars were fit with motion-activated mortality sensors. If a collar was motionless for > 12 h, we were alerted via email to the possibility that the mountain lion had died. We conducted field investigations immediately after receiving notification of potential mortality events and used data collected in the field to determine cause of mortality. This included evidence found directly on the body of the dead mountain lion (e.g., entrance wounds from canines or bullets, claw marks) and at the mortality site (e.g., tracks, drag marks, blood spatter, vegetation disturbance).

Note that all mountain lion monitoring data and cause of mortality information has been provided to the CDFW to be included in a meta-analysis aimed at determining cause-specific survival estimates for mountain lions in California (Benson, Dellinger et al. unpublished manuscript).

MOUNTAIN LION POPULATION DENSITY

We estimated the population density of mountain lions based on home range overlap (Rinehart et al. 2014). We estimated mountain lion densities across a 714 km² focal area where we believed we had captured and collared the majority of resident individuals occupying the area at the time and identified any uncollared mountain lions based on their tracks. The extensive network of public and logging roads and relatively mild winter conditions facilitated good coverage of the area in 4×4 vehicles to search for fresh tracks. Driving was supplemented by hiking in certain areas to maximize our search effort. Although we were only able to reliably ascertain individual mountain lion presence from tracks when snow was present on the ground, for comparative purposes we estimated densities within the focal area both for winter (Nov. 15, 2018 to Feb. 14, 2019) and summer (Jun. 1 to Aug. 31, 2018). Home ranges of mountain lions were estimated using the kernel plug-in bandwidth method based on GPS locations acquired at 2 h fix rates during the 3-months periods outlined above (Gitzen et al. 2006).

MOUNTAIN LION DIET & KILL RATES

To determine diet composition of mountain lions, we investigated location clusters identified by an algorithm initially developed by Knopff et al. (2009) and adapted by the Santa Cruz Mountain Lion Project (Wilmers et al. 2013) to locate potential kill sites. Cluster identification was automated and relied on 2 h fix rates of mountain lion collars, where ≥ 2 fixes were spatio-temporally constrained to occur within 100 m of each other within a 6 day timeframe (Wilmers et al. 2013). In the field, we carefully approached the area associated with a location cluster to locate potential prey remains and documented any evidence that helped us to determine whether it had been killed by a collared mountain lion or whether the animal had been scavenging. Evidence used to ascertain that a mountain lion had killed the prey included puncture wounds, bite and claw marks, broken vegetation, drag marks, animal tracks, and blood spatter. We identified prey species by their skeletal remains and external characteristics such as hair and feathers using a field guide (Elbroch & McFarland 2019). For mammals, we also attempted to identify the sex and age classes of the prey species. Finally, we collected a tooth at sites where we found remains of deer jaws for exact age determination using cement-annuli methods (Matson's Laboratory LLC, Missoula, MT, USA).

To obtain more precise estimates of mountain lion kill rates, we conducted intensive kill rate monitoring sessions of focal individuals. Kill rate monitoring sessions lasted for 28 days during which time we investigated all clusters where a mountain lion had remained for ≥ 2 hours. This followed results showing that estimates solely based on

investigations of longer clusters may bias kill rate estimates of mountain lions (Elbroch et al. 2018). We estimated kill rates both as the number of ungulates killed per week as well as ungulate biomass killed per day. To convert estimates based on the number of ungulates killed per week into biomass we used live weight estimates from different sources. For deer and elk of all age and sex classes we used data from Oregon (Clark et al. 2014), except for adult female deer for which we used Siskiyou-specific mean weight from live capture records for the project. Additional sources were used to obtain weights of pronghorn (Silva & Downing 1995), feral horse (Knopff et al. 2010), and cattle (UC 2004).

EFFECT OF SCAVENGERS ON MOUNTAIN LION KILL RATES

To quantify the potential impact of scavengers on mountain lion kill rates, we placed motion-activated video cameras (XR6, Reconyx, USA) at a subset of kills we discovered. We only placed video cameras at fresh kills to ensure we could confidently determine the timing of arrival of scavengers (Allen et al. 2015, 2016). To ensure we identified kill sites as quickly as possible, we visually identified potential candidate locations for camera deployment at kills by mapping mountain lion GPS locations in Google Earth as soon as they became available. We programmed cameras to record 30 s videos when triggered with a 5 s refractory period. Cameras remained active for at least 3 weeks or until batteries ran out. To limit the ability of scavengers to drag the carcass out of the field of view of our cameras, we anchored carcasses using rope. We tagged all videos using software BORIS (Friard & Gamba 2016). To reduce observer variability, all videos were tagged by the same individual. Variables recorded included the species triggering the camera, whether the individual(s) fed on the carcass, as well as the duration of feeding bouts. For mountain lions we developed a more complex ethogram that included behavioral states that were not restricted to feeding (e.g., resting, caching). We used the camera data to compare feeding times of mountain lions at carcasses with vs. without bear visitation.

RESULTS

SEASONAL DEER RANGES & MOVEMENTS

Based on available deer GPS location data in 2017, we identified 9 potential winter ranges. We also delineated 4 summer fawning ranges. Both winter and summer ranges are shown on Fig. 2.

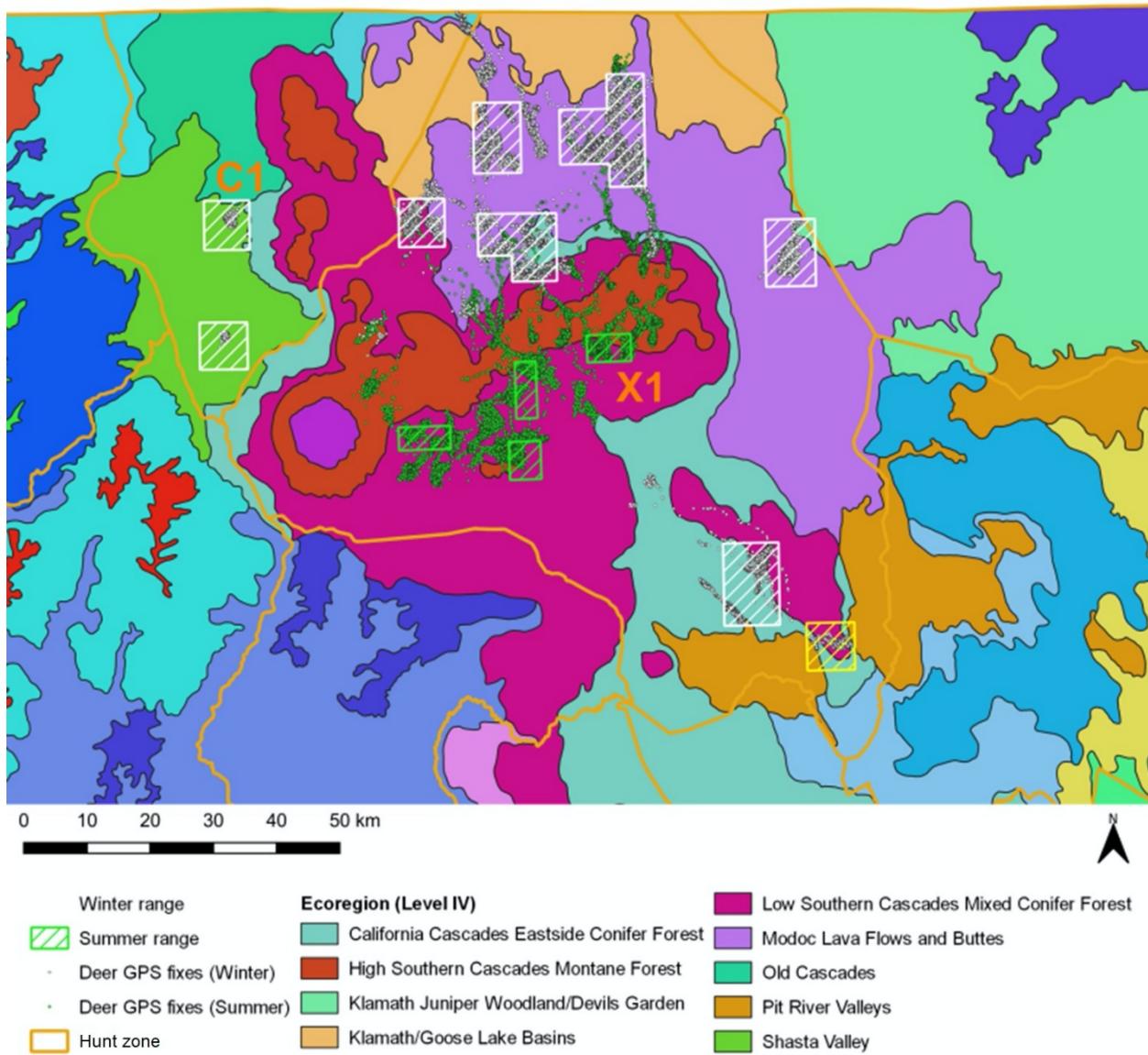


Fig 2. Summer (green, n = 4) and winter (white & yellow, n = 9) ranges of deer delineated as part of the Siskiyou deer-puma study in northern California between 2015-2020. One of the winter ranges (yellow rectangle) is a high elevation area that received little use based on deer pellet transect data and was therefore not included in our vegetation surveys. Seasonal ranges are overlaid with Level IV ecoregions (Environmental Protection Agency 2012) present in California.

We used 88 animal years from 78 unique adult female deer (i.e., we had two animal years' worth of data for 10 individuals) for our movement classification analysis. Of the 88 animal years, 4 were classified as residents, 67 as migrants, and we were unable to confidently classify the remaining 17 animal years to a specific movement strategy. Deer migrated an average of 53.5 km (n = 67, range = 12.7-83.9 km) between seasonal ranges. Seasonal migration strategies were complex and will require further investigation.

Approximately 10% of migratory animal years crossed HWY 97 (i.e., 7 out of 67, representing n = 60 unique individuals). None of the 7 individuals we had multiple animal-years classifications for crossed HWY 97, thus the effective percentage on an individual basis would be 7/60 or approximately 12%. Some deer crossed HWY 89, but none of these deer were classified as migratory. Seasonal migration corridors are highlighted in Fig. 3.

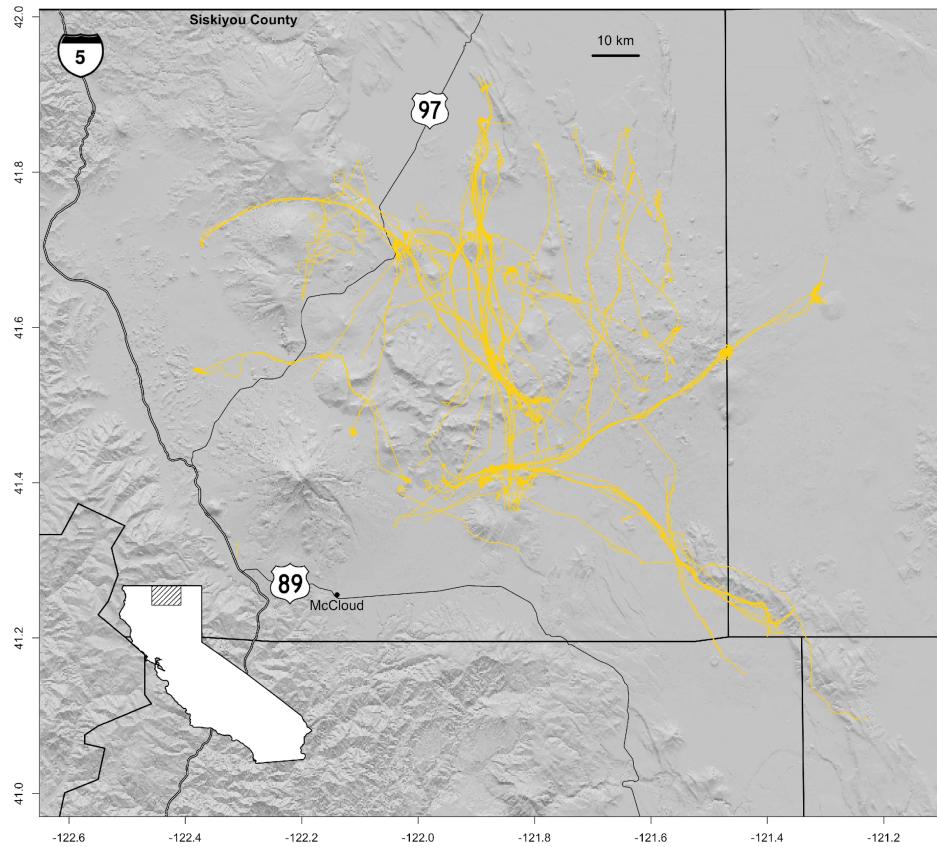


Fig. 3. Seasonal migration corridors between summer and winter ranges delineated as part of the Siskiyou deer-puma study in northern California between 2015-2020. Corridors based on GPS location data of 60 adult female deer.

FAWN CAPTURES

Between June 2016 and June 2019, we captured and collared a total of 145 fawns (67F/78M). Only 4 fawns (2F/2M) were captured during our pilot study in 2016. Annual sample sizes of collared fawns in subsequent years were 38 (14F/24M) in 2017, 51 (27F/24M) in 2018, and 52 (24F/28M) in 2019. The earliest fawn capture date was June 4, and the latest capture date was July 4. Only 3 fawns overall were captured in July. Both mean (18 June, 19 June, 19 June) and median (21 June, 20 June, 19 June) capture dates were similar across all 3 years with comparable capture efforts. Weights of fawns at capture averaged 4.71 kg (± 1.49 SD) and ranged from 2.30 kg to 8.90 kg.

Weights did not differ between female ($4.52 \text{ kg} \pm 1.43 \text{ SD}$) and male fawns ($4.87 \text{ kg} \pm 1.52 \text{ SD}$). Average capture weights were also comparable across years: $5.02 \text{ kg} (\pm 1.53 \text{ SD})$ in 2017; $4.70 \text{ kg} (\pm 1.49 \text{ SD})$ in 2018; $4.58 \text{ kg} (\pm 1.44 \text{ SD})$ in 2019. In all years, there was a significant positive trend between fawn weight and capture date; fawns caught later during the capture period were significantly heavier than those caught earlier (2017/18: $\beta = 0.010 \pm 0.023 \text{ SE}, P = 0.0001$; 2018/19: $\beta = 0.109 \pm 0.034 \text{ SE}, P = 0.0025$; 2019/20: $\beta = 0.127 \pm 0.029 \text{ SE}, P < 0.0001$). Detailed capture and monitoring information for individual fawns is summarized in Table A1.

FAWN SURVIVAL

Our sample sizes of collared fawns were large enough to estimate annual survival rates for 3 cohorts (2017/18, 2018/19, 2019/20). The overall mean annual survival rate of fawns ($n = 141$) was $0.316 (\pm 0.071 \text{ SE})$. Note that our data indicated that there was significant variation in annual survival rates ranging from $0.217 (\pm 0.063 \text{ SE})$ in 2018/19 to $0.461 (\pm 0.072 \text{ SE})$ in 2019/20 (Fig. 4). Also, the mean survival rate of fawns over the first 6 months of their life (June-November survival rate = $0.459 \pm 0.074 \text{ SE}$) was significantly lower when compared to the mean survival rate of fawns aged 7-12 months old (December-May survival rate = $0.687 \pm 0.109 \text{ SE}$). Estimating annual survival rates based on cohorts appears robust as pooling all individuals across all years into 1 estimable annual survival period returned very similar results (i.e., pooled mean annual survival rate = $0.324 \pm 0.042 \text{ SE}$, pooled mean summer survival = $0.458 \pm 0.042 \text{ SE}$; pooled mean winter survival = $0.706 \pm 0.065 \text{ SE}$).

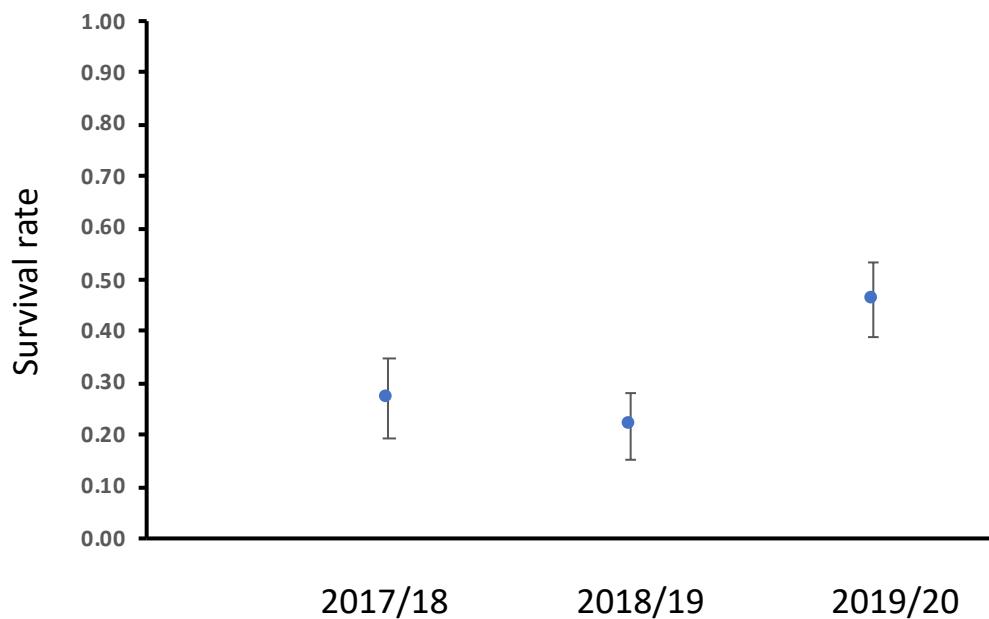


Fig. 4: Mean survival rates ($\pm \text{SE}$) for 3 cohorts of telemetered deer fawns < 1 year captured and monitored as part of the Siskiyou deer-puma study in northern California between June 2017 and May 2020.

FAWN CAUSES OF MORTALITY

Of the 145 fawns we captured, 91 were confirmed to have died during their first year of their lives. One fawn mortality site was investigated > 1 month after occurrence and was thereby classified as unknown and excluded from subsequent analyses. We investigated the remaining 90 mortality sites within 4.0 days (± 5.7 SD, range 0-30) after first recording a mortality signal. Without confidence level assignment (see methods), predation accounted for 77% of mortalities (Fig. 5). Coyotes ($n = 21$) and bears ($n = 17$) were the 2 most frequent predators of fawns with mountain lions ($n = 13$) and bobcats ($n = 9$) accounting for the remaining mortalities attributed to known predators. Nine additional fawn mortalities were attributed to predation without identifying a specific predator species. The remaining mortalities were due to roadkill ($n = 3$), natural hazards ($n = 2$), and unknown causes ($n = 16$). We did not identify malnutrition or disease as the cause of mortality of any fawn. Predation accounted for 38% of confirmed mortalities when only high confidence data were included.

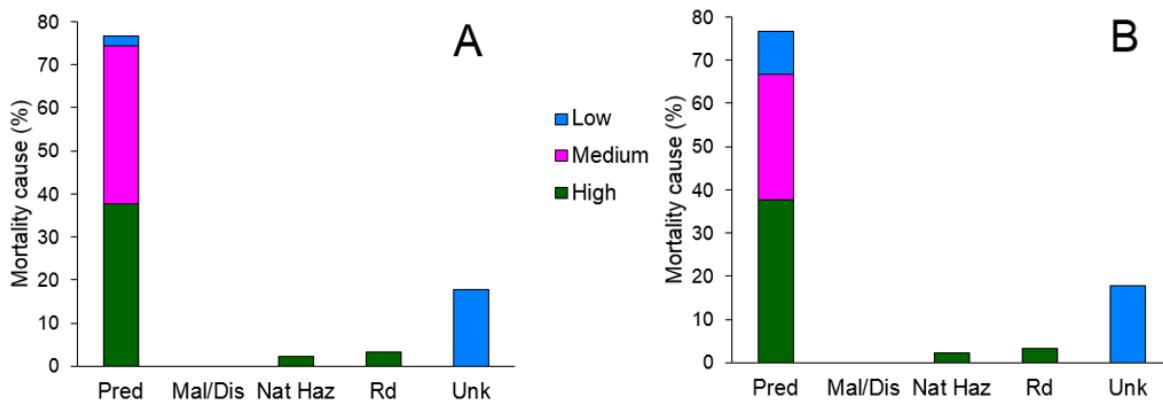


Fig. 5. Mortality causes for telemetered deer fawns < 1 year ($n = 90$; A – predator species pooled, B – predator species-specific cause of mortality) as part of the Siskiyou deer-puma study in northern California between June 2016 and May 2020. One additional recorded mortality is excluded due to the extensive time elapsed between mortality and field site investigation (> 1 month). Confidence level in cause of mortality assignment (Low, Medium, High) shown for each category. Pred = Predation, Mal/Dis = Malnutrition/Disease, Nat Haz = Natural Hazard, Rd = Roadkill, Unk = Unknown.

When predation was pooled across predator species, roadkills, as well as natural hazards, duration of the time interval between first recording a mortality signal and site visitation tended to impede our ability to identify cause of death for fawns (β Days elapsed = -0.089 ± 0.041 SE, $P = 0.029$; Fig. 6A). We identified a comparable outcome when recording predator species-specific predation on fawns, along with roadkills and natural hazards (β Days elapsed = -0.085 , SE = 0.040 , $P = 0.035$; Fig. 6B).

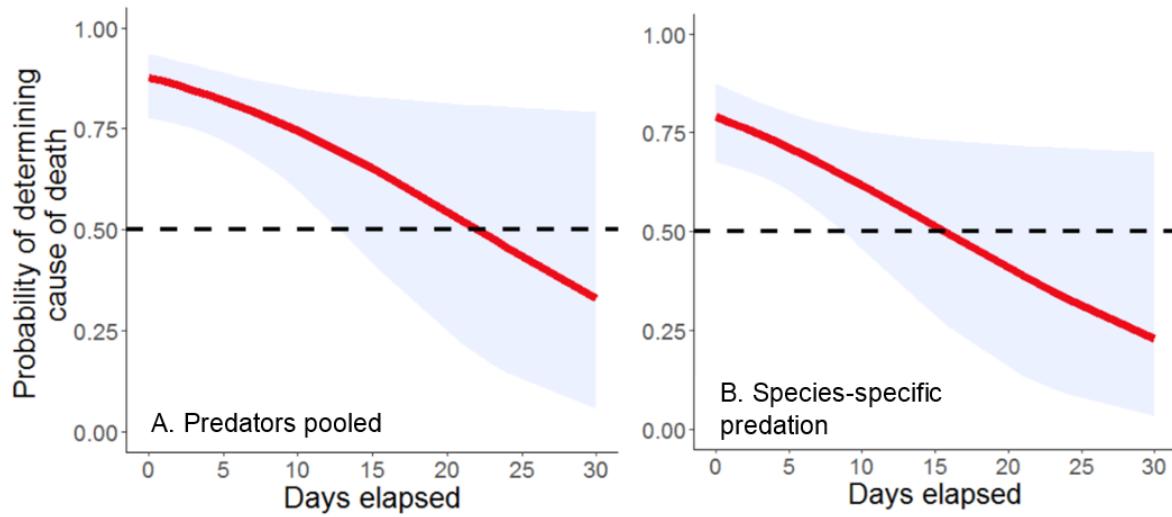


Fig. 6. Probability of assigning cause of mortality of deer fawns as a function of the number of days elapsed between mortality and site visitation by field crews, when predation records are pooled (A) or differentiated among predator species (B). 95% confidence levels are presented in grey shading. Data are for telemetered fawns confirmed dead ($n = 90$) as part of the Siskiyou deer-puma study in northern California between June 2016 and May 2020. The horizontal dashed line indicates the probability threshold ($P = 0.50$) for discriminating cause of death as per field procedures and conditions, which is not the same as probability that the discrimination was correct.

We used multinomial regression to understand how outcomes of field visitation varied with regard to confidence level in the cause of mortality assignment, based on the assumed number of days elapsed between the mortality event and site visit. The dependent multinomial variable had three levels: Low (reference category), Medium, or High confidence in mortality cause assessment, whereas elapsed time was the independent variable. For fawns, days elapsed did not influence classification of mortality with Medium confidence, when compared to Low confidence assignments. However, as the number of days elapsed increased, fawn mortalities were less likely to be classified with High confidence, a pattern that held for predation pooled across predator species (β Days elapsed = -0.164 ± 0.070 SE, $P = 0.019$; Fig. 7A) as well as predator species-specific kills of fawns (β Days elapsed = -0.161 , SE = 0.068 , $P = 0.018$; Fig. 7B). Roadkills and natural hazard mortalities were included in these analyses. The results provide additional support to the finding that fawn mortality site assessments depend on rapid site investigations.

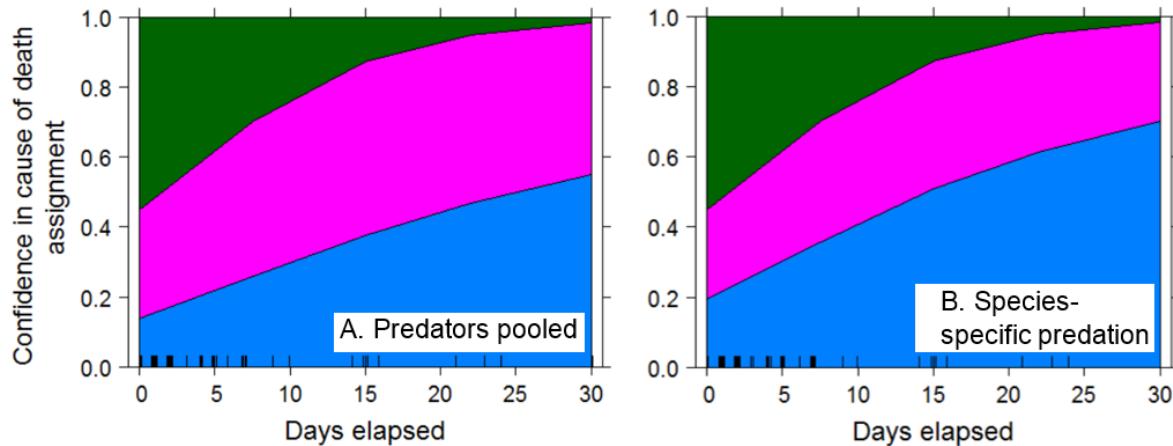


Fig. 7. Probability of confidence level for identifying cause of death of deer fawns as a function of number of days elapsed between mortality and site visitation by field crews. Data are presented for predation records pooled (A) or differentiated among predator species (B). Confidence levels in cause of mortality assignment were High (green), Medium (purple), or Low (blue). Data are for telemetered fawns confirmed dead ($n = 90$) as part of the Siskiyou deer-puma study in northern California between June 2016 and May 2020.

YEARLING DEER

A total of 29 collared fawns ($n = 12$ females and 17 males) transitioned to the yearling age class with functioning VHF collars. Due to low sample sizes, survival estimates were derived from data pooled for both females and males as well as across all years. The estimated mean annual survival rate of yearlings was 0.741 (± 0.161 SE). Only 2 of the yearlings we monitored died, with one mortality each occurring in December and January. Both mortalities were attributed to predation. Cause of mortality data of yearlings has been added to that reported for adults (see below).

ADULT DEER CAPTURES & MONITORING

Over the entire study period between March 2015 and June 2020 (the end of monitoring), a total of 86 adult female deer were captured, four of which died due to capture related complications (Table A2). The collar of 1 deer (ID110) only remained active for 4 days following capture and we excluded the individual from the survival analysis. Our effective sample thus consisted of 81 adult female deer. Two females originally collared in 2016 were recaptured in 2017 and fitted with new GPS collars. Weight of female deer at capture was recorded during 84 capture events and ranged from 39.13 to 77.50 kg (or approximately 86 to 171 pounds). The average weight of adult female deer was 59.71 kg (± 7.22 SD). Winter body condition scores averaged 1.59 (± 0.69 SD, $n = 22$) in 2015 and 2.56 (± 0.63 SD, $n = 16$) in 2018. Summer body condition scores averaged 2.93 (± 0.80 SD, $n = 15$) in 2016, 2.55 (± 0.69 SD, $n = 11$) in 2017, and 2.66 (± 0.58 SD, $n = 19$) in 2018. Accurate age estimates based on cementum annuli were limited to 47 of the 81 adult female deer we monitored. The limited number of age information available was due to a variety of causes including

loss of all tooth samples collected during 2015 ($n = 25$ captures) and no tooth samples being collected during all captures in 2017 ($n = 9$). The average age of collared female deer based on cementum annuli was 4.55 years (± 2.57 SD, range from 2 to 11) at capture. Note that this estimate includes 2 individuals classified as yearlings based on the cementum annuli method that we reclassified as 2-year-olds based on tooth eruption patterns observed during capture. Based on the average capture age, our sample of collared deer should be considered representative of prime aged females. The status of collared adult females was on average monitored for 602 days (± 444 SD, range from 14 to 1,846). Over this time, we collected a total of 457,958 GPS locations. The average number of GPS locations collected per individual was 5,654 ($\pm 3,696$ SD, range from 27 to 15,921). In some instances, we were able to continue monitoring the fate of individuals after their GPS collar had either dropped or failed using ground-based monitoring of VHF collars that remained active. Further information including age estimates based on tooth wear and eruption patterns as well as capture weights are shown in Table A2.

DEER PREGNANCY RATES & NUMBER OF FETUSES

Pregnancy rates were assessed for $n = 25$ females in 2015 and $n = 16$ females in 2018. The mean pregnancy rate of adult females was 0.949 (± 0.016 SD). None of the females assessed for pregnancy was classified as a yearling. When we adjusted our pregnancy rates of adult females based on data provided in Monteith et al. (2014) we estimated a mean pregnancy rate of 0.659 (± 0.016 SD) for yearlings (i.e., $0.694 * 0.949$).

The number of fetuses *in uteri* was determined for 24 pregnant females in 2015 and 15 pregnant females in 2016. The overall mean number of fetuses was 1.863 (± 0.100 SD). Note that the number of fetuses per female needs to be divided by 2 to account for the number of female fetuses before it can then be used to estimate population growth from a population matrix.

ADULT FEMALE DEER SURVIVAL

Survival rates of adult female deer were estimative from April 2015 onwards, the first full month of monitoring. Monitoring of adult females finished at the end of June 2020. Over this period, we on average monitored 26.33 (± 10.53 SD) females/month. We considered this sample size large enough to allow meaningful estimates of monthly survival probabilities. Using a monthly survival interval also matched our ground-based monitoring schedule to determine status of adult deer once their GPS collars had dropped or failed.

When calculating yearly (12-months) survival rates from April 2015 onwards, the mean annual survival probability of adult females was 0.838 (± 0.068). This estimate is based on 5 full years of data but excludes spring (April-June) 2020. Two collared females died during this final monitoring period. The number of females remaining with active collars had dropped to between 10 and 11 during this time, making estimates of survival potentially more susceptible to small samples of animals at risk of dying. However, there

appears to have been little effect from our decision to exclude data from the final 3 months of monitoring as annual survival rates based on observed seasonal survival probabilities that included data for spring 2020 resulted in a comparable estimate (i.e., mean annual survival rate of adult females of 0.831 ± 0.036). Finally, there was no significant seasonal and/or annual variation (Fig. 8) in adult female survival over the 5-year duration of our study.

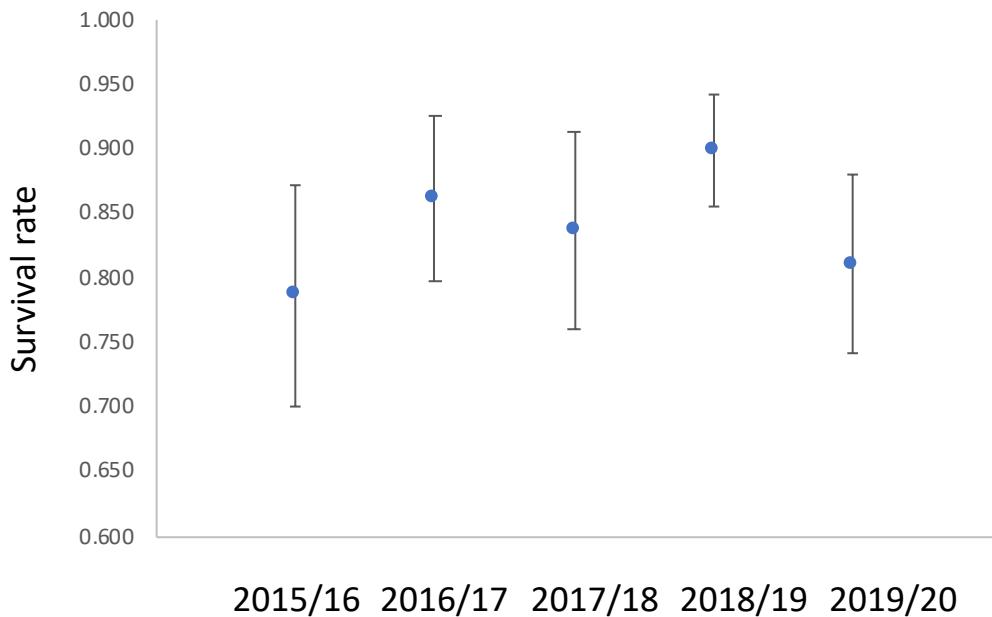


Fig. 8: Mean annual survival rates (\pm SE) of female deer collared as part of the Siskiyou deer-puma study in northern California between 2015 and 2020.

ADULT DEER CAUSES OF MORTALITY

Four females died of capture-related mortality. Of the 81 adult females we monitored (i.e., excluding ID110), 26 (32%) were confirmed to have died over the course of the study. One of these mortalities was investigated > 3 months after occurrence and five of the mortalities occurred in 2015, when mortality site visitation was opportunistic and detailed records of mortality site investigations by CDFW personnel were not available. These mortalities were therefore all considered unknown and excluded from statistical analyses aimed at understanding confidence in cause of mortality assessment. However, two of the collared fawns that survived their first year of life and died as yearlings (Y003 and Y007, both males) were included for analyses with the adult females.

We investigated mortality sites of deer > 1 year old on average 8.3 days (± 10.4 SD, range 0–36) after recording a mortality signal. Without confidence level assignment, predation accounted for 70% of the mortalities recorded (mountain lion = 10, coyote = 5, predator not identified = 1) (Fig. 9A). The remaining mortalities were due to malnutrition or suspected disease ($n = 2$) and unknown causes ($n = 4$, note that this does not

include one mortality that was investigated > 3 months after occurrence, as well as the 5 mortalities in 2015). With confidence level assignment, predation accounted for only 32% of mortalities when only high confidence data were included.

Contrary to fawns, the number of days elapsed did not significantly influence our ability to assign the cause of death for deer > 1 year old (Fig. 9B).

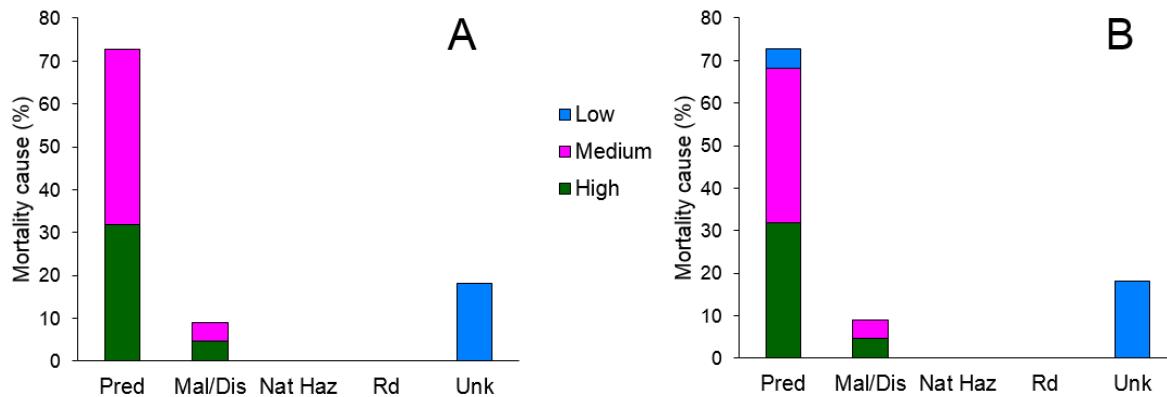


Fig. 9. Mortality cause for 22 marked deer > 1 year (yearlings = 2, adults = 20; A – predator species pooled, B – predator species-specific cause of mortality) as part of the Siskiyou deer-puma study in northern California between June 2016 and June 2020. One additional mortality is excluded due to extensive time elapsed between mortality and field site investigation (> 3 months). Confidence level in cause of death assignment (Low, Medium, High) shown for each category. Earlier data on adult mortality (2015; n = 5) were collected opportunistically and are therefore not included in the graphs. Pred – Predation, Mal/Dis – Malnutrition/Disease, Nat Haz – Natural Hazard, Rd – Roadkill, Unk – Unknown.

DEER POPULATION GROWTH

We used parameter estimates shown in Table 1 to construct our post-breeding Lefkovitch matrix and estimate population growth lambda. Results from the matrix model indicate the population should increase at a mean annual lambda = 1.027 (95% CI = 0.879-1.159). Lambda was most sensitive to changes in adult and fawn survival and least sensitive to changes in the number of fetuses and pregnancy rate of yearlings (Table 1). Lower-level elasticity estimates confirmed the importance of age-specific survival, particularly of adult females, over reproductive rates.

Table 1: Parameter estimates used in the post-breeding Lefkovitch projection matrix as well as sensitivity estimates of vital rates and elasticity estimates of matrix elements.

Vital rates & matrix elements	Parameter estimates	Sensitivity (vital rate)	Elasticity (matrix element)
Fawn survival	$\phi_f = 0.316 \pm 0.071$ (SE)	0.487	0.150
Yearling survival	$\phi_y = 0.741 \pm 0.161$ (SE)	0.208	0.129
Adult female survival	$\phi_a = 0.838 \pm 0.068$ (SE)	0.859	0.571

Pregnancy rate yearlings	$py = 0.659 \pm 0.016$	0.032
Pregnancy rate adults	$pa = 0.949 \pm 0.016$	0.140
Number of fetuses	$Nf = 1.863 \pm 0.100$	0.083
Sex ratio	50:50	0.308
Reproductive rate yearlings	$ry = py^*(Nf/2)^*\phi_y$	0.020
Reproductive rate adults	$ra = pa^*(Nf/2)^*\phi_a$	0.129

DEER POPULATION DENSITY

Total adult deer densities were 6.01 km^{-2} ($\pm 2.13 \text{ SE}$) on summer ranges in 2017 and 5.16 km^{-2} ($\pm 0.68 \text{ SE}$) on winter ranges in 2019 and did not differ significantly (Fig. 10). Fawn densities, however, differed significantly between summer and winter ranges. Doe to buck ratios were $4.42/1.60 = 2.76:1$ on summer range and $3.52/1.63 = 2.16:1$ on winter ranges.

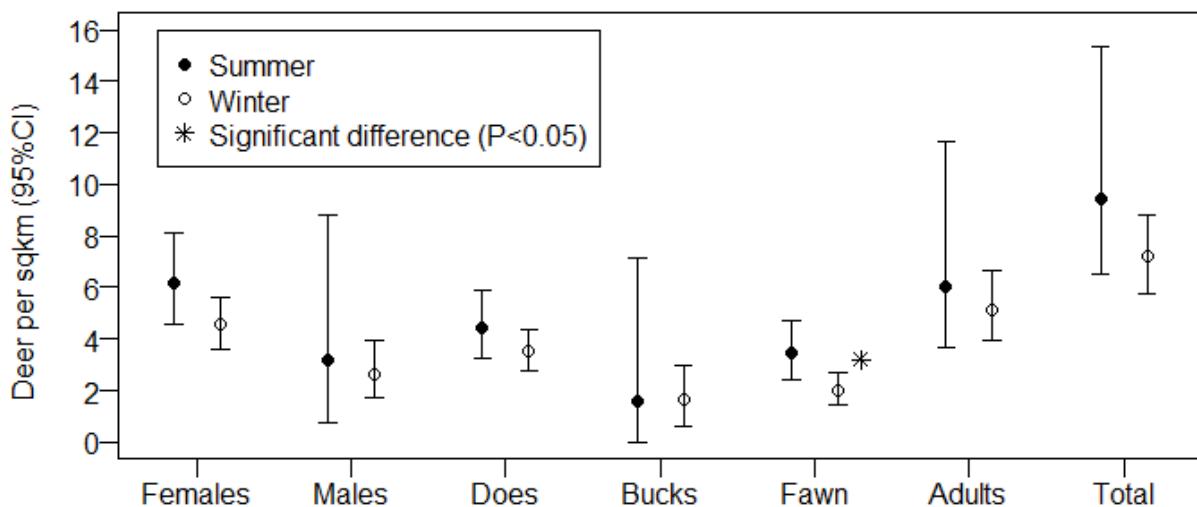


Fig. 10: Estimates of deer density on summer and winter ranges as part of the Siskiyou deer-puma study in northern California, by age and sex class. Densities estimated using spatially explicit capture-recapture (SECR) methods on DNA data derived from pellets collected on transects on 4 summer ranges (2017) and 8 winter ranges (2019).

DEER DIET

We sampled vegetation along 40 line intercept transects per summer range for a total of 160 transects. We sampled vegetation along a total of 148 transects on 8 winter ranges (mean = $18.5 \pm 1.3 \text{ SE}$, range = 13-24). Based on length x width measurements and/or proportion of intercepts on transect lines, we identified several shrub species that comprised $\geq 5\%$ cover on at least one of the 4 summer and 8 winter ranges. These shrub species are listed in Tables 2 and 3. Percentage cover calculations of woody vegetation available to deer on summer ranges do not include conifers. This is because even though we quantified the percentage cover of *Abies spp.* (fir) along line intercept transects and firs had higher cover than shrubs on all 4 summer ranges, we found no evidence of browsing on conifers in summer.

Table 2. Nutritional quality of shrubs species occupying $\geq 5\%$ cover on summer ranges of X1 deer hunt zone.

Species	GE (cal/g)	% CP	% NDF	% ADF	% ADL	% AIA	Tannin
<i>Amelanchier alnifolia</i>	4758	10.7	42.9	27.0	9.7	0.2	0.07
<i>Arctostaphylos nevadensis</i>	4401	6.4	29.9	22.4	11.9	0.1	0.14
<i>Arctostaphylos</i> spp.	4947	8.6	27.2	20.7	10.9	0.5	0.10
<i>Ceanothus velutinus</i>	4983	12.8	20.6	14.8	5.4	0.2	0.09
<i>Chrysolepis sempervirens</i>	4948	10.1	44.6	31.8	11.6	0.4	0.11
<i>Ericameria</i> spp.	4952	12.4	29.9	21.5	6.7	0.2	0.00
<i>Prunus emarginata</i>	4816	12.8	40.3	21.7	9.2	0.1	0.05
<i>Quercus kelloggii</i>	4765	14.8	39.4	23.1	8.5	0.4	0.12
<i>Ribes cereum</i>	4914	10.4	25.4	19.6	8.3	0.2	0.08
<i>Ribes roezlii</i>	4386	9.8	33.4	24.7	8.1	0.3	0.10
<i>Salix</i> spp.	4774	13.3	26.0	17.3	7.0	0.2	0.11
<i>Symphoricarpos mollis</i>	4782	10.4	30.9	20.4	7.6	0.2	0.00

Table 3. Nutritional quality of shrubs and select conifer species occupying $\geq 5\%$ cover in winter range areas of X1 deer hunt zone.

Species	GE (cal/g)	% CP	% NDF	% ADF	% ADL	% AIA	Tannin
Shrubs							
<i>Arctostaphylos</i> spp.	5070	6.1	23.1	17.0	9.6	0.2	0.12
<i>Artemisia arbuscula</i>	5160	13.1	28.7	22.4	6.1	0.3	0.00
<i>Artemisia tridentata</i>	5289	11.0	26.9	21.1	6.6	0.1	0.00
<i>Ceanothus cuneatus</i>	5024	11.3	42.5	32.1	16.2	0.1	0.09
<i>Ceanothus integerrimus</i>	4787	11.7	52.1	37.5	8.4	0.2	0.09
<i>Ceanothus prostratus</i>	4892	9.1	28.1	20.0	9.2	0.2	0.11
<i>Ceanothus velutinus</i>	5128	10.8	20.6	13.7	5.5	0.1	0.16
<i>Cercocarpus betuloides</i>	4936	10.5	48.3	34.7	15.2	0.1	0.08
<i>Cercocarpus ledifolius</i>	5288	11.0	33.7	23.9	11.7	0.1	0.09
<i>Ericameria</i> spp.	5317	11.4	37.4	28.5	9.0	0.2	0.00
<i>Eriogonum</i> spp.	4555	11.4	21.2	14.8	3.1	0.2	0.07
<i>Purshia tridentata</i>	5184	11.4	39.9	34.5	18.6	0.2	0.08
<i>Quercus garryana</i>	4706	5.8	49.6	34.9	14.7	0.3	0.10
<i>Rhus trilobata</i>	5125	9.4	35.8	27.3	11.6	0.3	0.11
<i>Symphoricarpos albus</i>	4806	6.9	60.9	41.9	15.9	0.2	0.00
Conifers							
<i>Abies concolor</i>	5065	6.6	31.1	21.2	10.1	0.3	0.08
<i>Juniperus</i> spp.	5557	7.4	28.3	19.9	9.6	0.3	0.08
<i>Pinus ponderosa</i>	5469	8.1	39.8	27.6	11.2	0.4	0.09
<i>Pseudotsuga menziesii</i>	5216	6.9	39.1	26.2	13.4	0.2	0.09

Vegetation cover differed among summer ranges (Fig. 11). Buck Mountain and Fons Butte had the greatest cover of both forbs (e.g., *Gayophytum* spp., *Horkelia fusca*) and shrubs (e.g., *Chrysolepis sempervirens*, *Ceanothus* spp.). Asperin Butte had comparable cover of Graminoids with the 2 aforementioned ranges but had comparatively low cover of forbs and shrubs. Red Hill, which was the highest elevation summer range and encompassed extensive solidified lava formations, had low overall vegetation cover compared to the other 3 summer ranges.

Winter ranges varied widely in vegetation cover both within and among ranges (Fig. 11). Overall, Tionesta had the greatest cover of forbs, Mount Dome the greatest cover of Graminoids, and Day Bench the greatest shrub cover (e.g., *Ceanothus* spp., *Cercocarpus* spp.). Sheep-Mahogany Mountains range had the greatest cover of conifers (mainly *Juniperus* spp.) within the 1.8 m height accessible to deer.

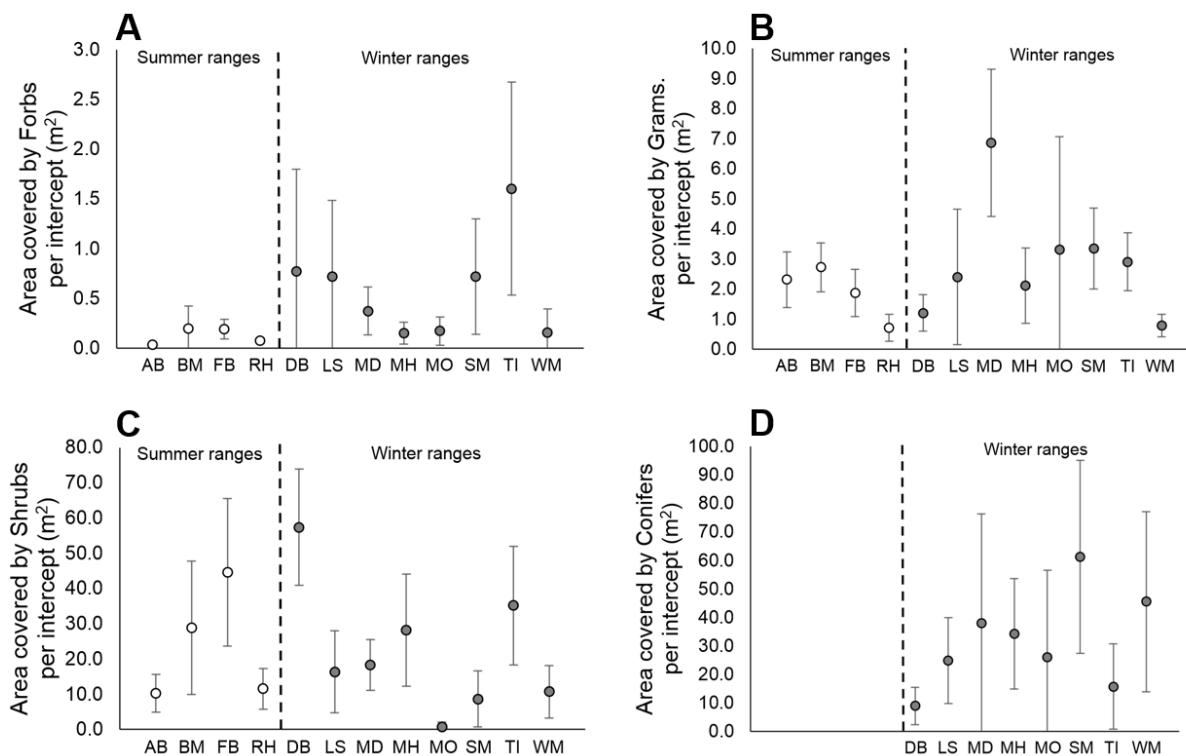


Fig. 11. Percentage cover of vegetation that are potential deer graze (Forbs (A), Graminoids (B)) or browse material (Shrubs (C), Conifers (D)) on deer hunt zone X1 summer and winter ranges. Data are vegetation cover (length x width) standardized per 100 m line-intercept transect. Summer ranges were sampled with randomly distributed transects, whereas winter ranges were assessed using stratified random sampling by land cover (CALVEG) class. The only Conifers assessed on summer ranges were firs (*Abies* spp.) but these data are not presented because no browsing on fir was identified on summer ranges. Error bars are $\pm 95\%$ confidence intervals. Ranges are coded for summer (n = 4; AB - Asperin Butte, BM - Buck Mountain, FB - Fons Butte, RH - Red Hill) and winter (n = 8; DB - Day Bench, LS - Lake Shastina, MD - Mount Dome, MH - Mount Hebron, MO - Montague, SM - Sheep-Mahogany Mountains, TI - Tionesta, WM - Wildhorse Mountain).

The taxonomic composition of vascular vegetation sampled was not homogeneous among ranges, with some ranges having disproportionately higher richness of plant genera (Table 4). On summer ranges, we detected the highest number of forb and shrub genera along line intercepts at Fons Butte and Buck Mountain. On winter ranges, we identified the highest number of shrub genera at Day Bench, Tionesta and Sheep-Mahogany Mountains. When we standardized richness of genera by the number of transects sampled per range, we found that Day Bench maintained the top rank, followed by Sheep-Mahogany Mountains and Wildhorse Mountain ranges. Mount Hebron, Day Bench and Wildhorse Mountain had the highest species richness of conifers.

Table 4. Richness of vascular plant genera on summer and winter ranges. Frequency of plant genera encountered along line intercepts are provided, with values in brackets representing frequencies standardized through dividing by the number of transects sampled per range (summer: AB - Asperin Butte, BM - Buck Mountain, FB - Fons Butte, RH - Red Hill; winter: DB - Day Bench, LS - Lake Shastina, MD - Mount Dome, MH - Mount Hebron, MO - Montague, SM - Sheep-Mahogany Mountains, TI - Tionesta, WM - Wildhorse Mountain). Dashes correspond to genera not recorded or pooled.

Season	Range	Forb	Gram	Shrub	Conifer
Summer	AB	14 (0.35)	-	11 (0.28)	-
	BM	24 (0.60)	-	13 (0.33)	-
	FB	30 (0.75)	-	16 (0.40)	-
	RH	12 (0.30)	-	12 (0.30)	-
Winter	DB	-	-	13 (0.62)	5 (0.24)
	LS	-	-	7 (0.35)	1 (0.05)
	MD	-	-	7 (0.33)	1 (0.05)
	MH	-	-	8 (0.44)	5 (0.28)
	MO	-	-	3 (0.23)	1 (0.08)
	SM	-	-	9 (0.56)	2 (0.13)
	TI	-	-	10 (0.42)	3 (0.13)
	WM	-	-	8 (0.53)	4 (0.27)

Of 12 shrub species on deer summer ranges for which nutritional quality was quantified (Table 2), the 5 species with the highest gross energy values were recorded to have on average > 4900 cal/g. However, they differed in % crude protein as well as the components that are mostly indigestible (e.g., fiber, lignin, tannin). These patterns will be investigated in detail once in vitro dry matter digestibility (IVDM) values become available from the processing laboratory, but *Ceanothus velutinus* appears to be one of the key high quality forage shrubs on summer ranges.

Of 15 shrub and 4 conifer species on deer winter ranges for which nutritional quality was quantified (Table 3), the top 3 species of shrubs as well as the top 3 species of conifers contained gross energy values that exceeded 5200 cal/g. However, the respective shrub species had substantially greater % crude protein content than the conifers. Additional differences were recorded with regard to digestibility, but these patterns will be investigated in detail when IVDM values become available. However,

Artemisia spp. and *Ericameria* spp. appear to be some of the important high quality forage shrubs on winter ranges.

PREDATOR MONITORING

a) *Predator communities at fawn capture sites:* Black bears were the predator species recorded in the highest relative abundance from camera traps deployed at fawn capture sites on deer hunt zone X1 fawning ranges (Fig. 12). Coyotes were the second highest numerically, whereas Felids (bobcats and mountain lions) were recorded with substantially lower frequencies. Correspondingly, detection rates (proportion of camera trap stations that captured predators) were highest for black bears ($p = 0.721$) and coyotes ($p = 0.597$), and considerably lower for bobcats ($p = 0.147$) and mountain lions ($p = 0.062$).

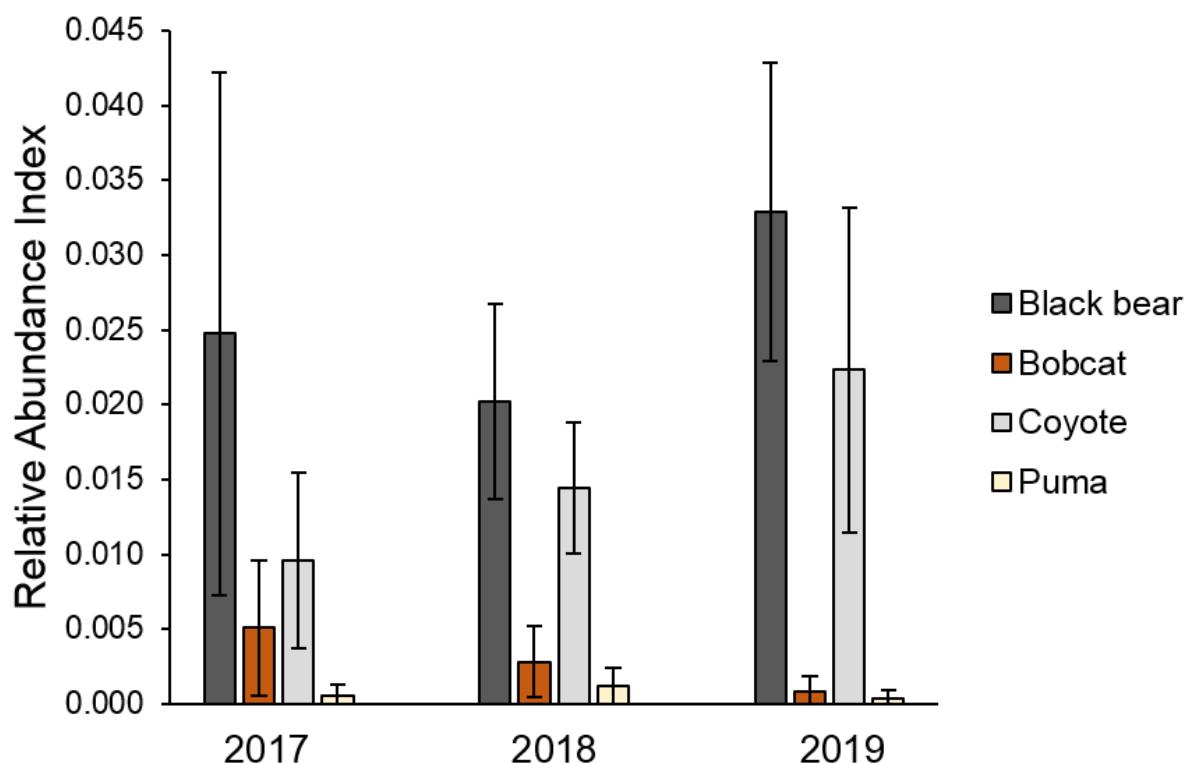


Fig. 12: Relative abundance indices for predators using fawning areas in X1 deer hunt zone in the summer. The indices are calculated as the number of photographs of a given predator species per camera trap night and include all predator photos irrespective of time between subsequent camera triggers. Data include all predator detections in trigger 1 of the camera trap units. Error bars show 95% confidence intervals.

b) *Predator communities on summer and winter ranges:* We obtained data on predator occurrence and distribution from 48 and 80 cameras in summer and winter, respectively. Four additional cameras set in winter did not provide data because of memory card failure (2), cameras being knocked over by cattle within 2 days of deployment (1), and cameras lost to wildfire (1). All cameras on summer ranges were

active for 90 days, whereas the 80 cameras on winter ranges that provided data were active for 88.43 (± 0.93 SE) days (range = 40-90). We estimated detection and relative abundance indices based on cameras that were active for ≥ 40 nights.

Summer ranges: Black bears were by far the most widely distributed predator (Fig. 13), being detected at most cameras ($p = 0.875$). Bobcats ($p = 0.500$) and coyotes ($p = 0.417$) were relatively widespread, whereas mountain lions were detected at < 10 cameras ($p = 0.146$). Relative abundance indices revealed similar patterns (Fig. 14).

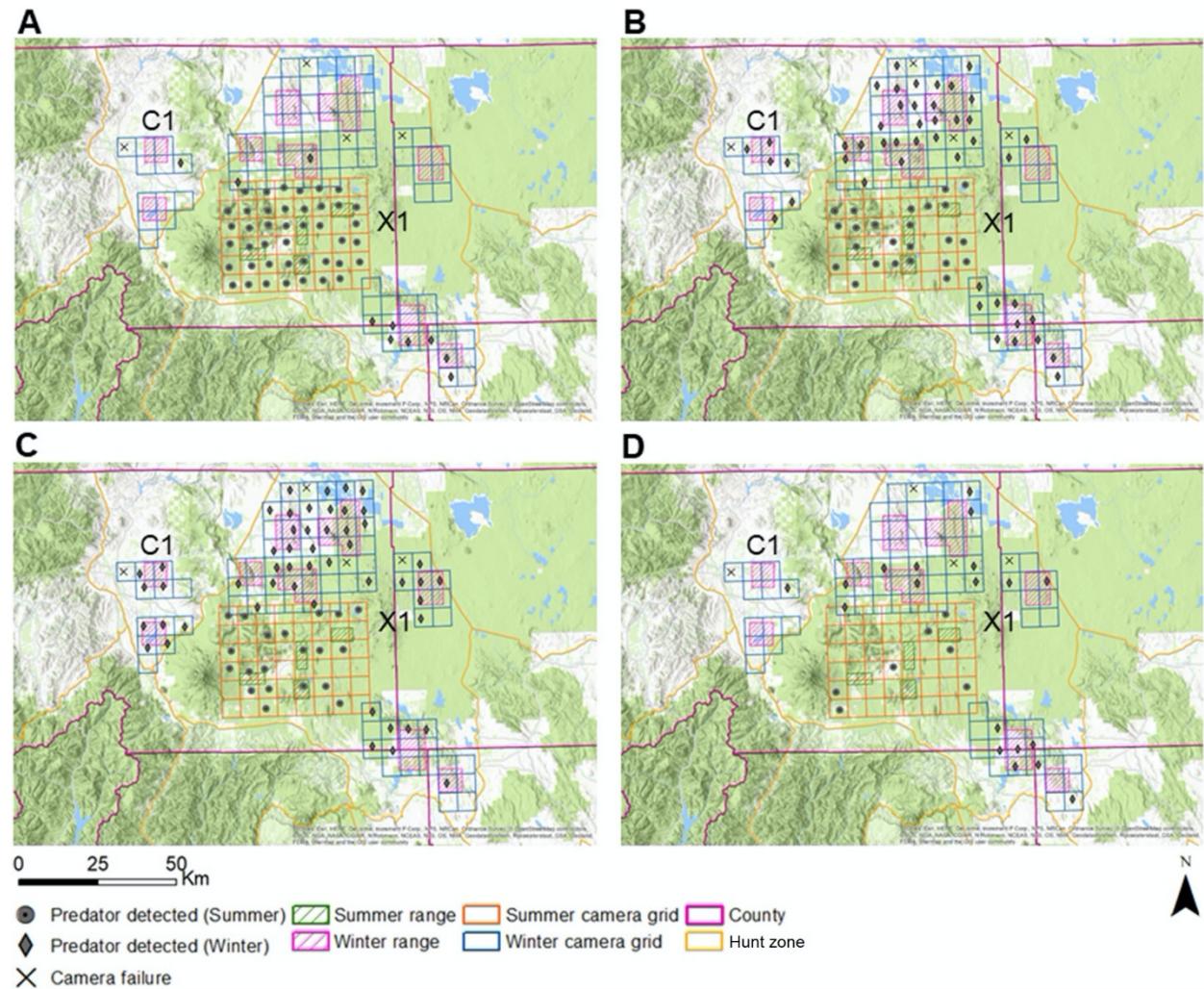


Fig. 13: Detections of black bear (A), bobcat (B), coyote (C), and mountain lion (D) by camera traps active in summer 2019 and winter 2019-2020 in X1 deer hunt zone.

Winter ranges: Coyotes ($p = 0.638$) and bobcats ($p = 0.600$) were each detected at more than half of the cameras (Fig. 14). Mountain lions were detected more than on summer ranges, but still at < 20 cameras ($p = 0.238$). Black bears were least detected ($p = 0.125$), which was not surprising given the winter timeframe of the sampling, when many bears are presumably hibernating in their winter dens. Relative abundance

indices revealed patterns that were comparable to those from detection values. Interestingly, some bears were active in winter and a concentrated pattern of use was apparent in the South-East section of the study area (Fig. 13).

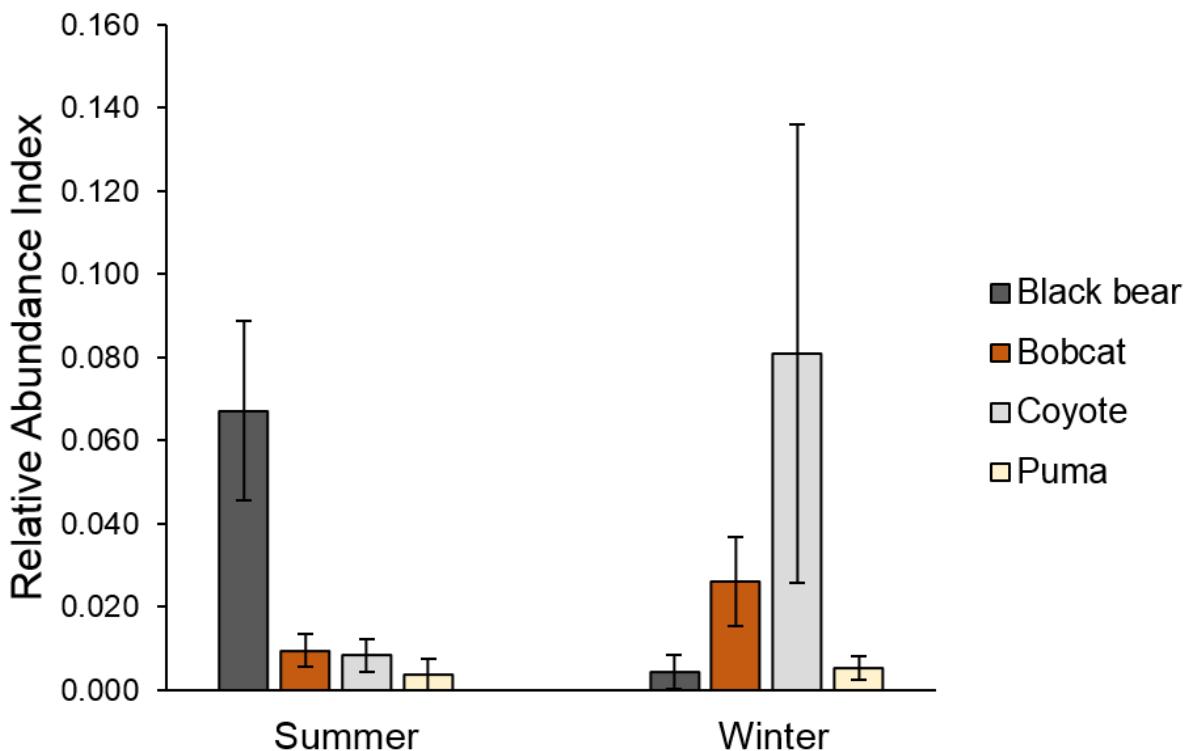


Fig. 14: Relative abundance indices for predators using summer and winter areas in X1 deer hunt zone. Camera trap stations were active in summer 2019 (summer areas) and winter 2019–2020 (winter areas). The indices are calculated as the number of photographs of a given predator species per camera trap night and include all predator photos irrespective of time between subsequent camera triggers. Data include all predator detections in trigger 1 of the camera trap units. Error bars are $\pm 95\%$ confidence intervals.

MOUNTAIN LION CAPTURES

Over the duration of the project, we captured and collared a total of 15 mountain lions (Table 5). One mountain lion (11F) died during capture and our effective sample thus consisted of 14 individuals (5 females, 9 males). Four mountain lions were recaptured and fitted with new collars either because their initial collars failed or to replace batteries. The estimated age of mountain lions at capture varied between 2 and 7 years; since all mountain lions were independent at the time of their capture, we considered all to be adults for subsequent analyses. One mountain lion (10M), however, dispersed following capture indicating that a more permanent home range had not yet been established. With the exception of 2F, who died within 1 month of collaring, all female mountain lions were at times recorded with kittens. The confirmed number of kittens accompanying collared mountain lions ranged from 1 to 3. These observations confirm a reproductively active mountain lion population but cannot be used to estimate litter size.

Table 5: Status of mountain lions captured/recaptured and monitored as part of the Siskiyou deer-mountain lion project, 2017-2020.

Mountain lion ID	Capture date	Capture method	Sex (reproductive status)	Age years (Estimated)	Weight (lbs)	Last Date Alive	Mortality Date	Number GPS Fixes (2h)	Number GPS Fixes (5 min)	Status (mortality cause)
1F	29-Jan-17	Hound	F (w/ kittens)	5	77.7	8-May-17	NA	600	0	Recaptured
1F	8-May-17	Hound	F (w/ & w/o kittens)	5	87.2	8-Jul-19	NA	8940	16064	Dropped collar
2F	12-Feb-17	Hound	F	2-2.5	90.5	7-Mar-17	7-Mar-17	268	0	Dead (poached)
3M	27-Feb-17	Hound	M	2.5	106.8	10-Jan-19	10-Jan-19	7957	16025	Dead (killed by train)
4M	7-Mar-17	Hound	M	3.5	158.5	19-Aug-17	NA	1136	0	Recaptured
4M	28-Jan-18	Hound	M	4.5	146.9	5-Dec-18	5-Dec-18	3543	16098	Dead (poached)
5M	8-Mar-17	Hound	M	4.5	124	14-Mar-18	NA	3929	0	Recaptured
5M	25-May-18	Cage	M	6	114.3	12-Oct-19	12-Oct-19	5652	15348	Dead (killed by another mountain lion)
6M	8-Nov-17	Hound	M	3	127.4	25-Nov-17	25-Nov-17	193	614	Dead (roadkill)
7M	9-Dec-17	Cage	M	3	134.2	31-Jan-19	NA	4735	8033	Recaptured
7M	31-Jan-19	Hound	M	4	104.8	17-Feb-19	17-Feb-19	162	0	Dead (poached)
8F	21-Dec-17	Hound	F (w/ kittens)	4.5	76.7	14-Feb-19	NA	4848	23681	Dropped collar
9F	4-Mar-18	Hound	F (w/ & w/o kittens)	3	95.4	28-Apr-19	NA	4844	16029	Dropped collar
10M	31-Oct-18	Hound	M	2.5	105.6	25-Feb-20	NA	5543	0	Dropped collar
11F	17-Nov-18	Hound	F	6-7	73.1	18-Nov-18	18-Nov-18	NA	NA	Capture mortality
12M	14-Dec-18	Cage	M	5	136	12-Feb-20	12-Feb-20	4874	16072	Dead (killed by another mountain lion)
13F	12-Feb-19	Hound	F (w/ kittens)	6	90.5	29-Feb-20	NA	4330	23864	Dropped collar
14M	20-Mar-19	Cage	M	6	132.5	6-Jul-20	NA	5504	8018	Dropped collar
15M	18-May-19	Cage	M	5.5	118.2	10-Jul-19	10-Jul-19	589	0	Dead (killed by another mountain lion)

MOUNTAIN LION MONITORING & CAUSES OF MORTALITY

Mountain lions were on average monitored for 449 days (± 286 SD, range 17-948) and we retrieved a total of 67,647 locations recorded at 2 h intervals and 159,846 locations recorded at 5 min intervals from their collars. Three collars malfunctioned and were replaced by recapturing the animals. Overall fix success rates for functioning collars were high (94%).

Eight of the 14 collared mountain lions died while being monitored (Table 5). Three mountain lions were illegally killed, 3 were killed by other mountain lions, and 2 were killed due to accidents (one vehicle and one train collision, respectively). Note that monitoring and cause of mortality data of collared mountain lions has been provided to CDFW to be included in a state-wide mountain lion survival and cause-specific mortality analysis.

MOUNTAIN LION POPULATION DENSITY

Seven collared mountain lion individuals were simultaneously monitored in winter 2018-2019 and summer 2018 and overlapped the focal area delineated for density estimation. Home ranges of these individuals included the Butte Valley landscape as well as component and adjacent rugged terrain in the X1 deer hunt zone, and some animals also used the C1 deer hunt zone.

Mean winter home ranges size was slightly larger for females ($354 \text{ km}^2 \pm 145$ SD, range = 253-520, n = 3) than for males ($308 \text{ km}^2 \pm 114$ SD, range = 168-417, n = 4). Proportion overlap of home ranges with the focal area was < 0.5 per individual (range = 0.03-0.44) and totaled 1.55 adult collared mountain lions for the 714 km^2 area. The corresponding standardized density was 0.22 adult mountain lions per 100 km^2 . Two additional adults (one female, one male) were present but seldomly tracked and appeared spatially restricted on two outer edges of the focal area, possibly indicating low overlap.

Assuming they were residents, and that each had 0.5 overlap with the focal area, yields a maximum total of 2.55 adult mountain lions, or 0.36 adults per 100 km^2 . Therefore, adult mountain lion winter density can be given as a range of 0.22-0.36/ 100 km^2 .

In summer, the mean home range size of males ($627 \text{ km}^2 \pm 107$ SD, range = 491-753, n = 4) was larger than for females ($327 \text{ km}^2 \pm 65$ SD, range = 252-367, n = 3). Proportion overlap of home ranges with the focal area was again < 0.5 per mountain lion (range = 0.07-0.47) and summed up to 1.56 adult collared animals in the 714 km^2 . The equivalent density in a standardized form was 0.22 adult mountain lions per 100 km^2 , which was similar to the winter estimates. Assuming that one adult female and one adult male that were uncollared were residents and used the area in the summer, with each overlapping 0.5 with the focal area, the overall density of adults was 2.56, or 0.36 adults per 100 km^2 . Adult mountain lion summer density could then be given as a range of 0.22-0.36/ 100 km^2 , which is the same as in winter.

While the overall densities of adult mountain lions appeared similar in winter and summer, collar data indicate intra- and inter-individual differences in space use between seasons (Fig. 15).

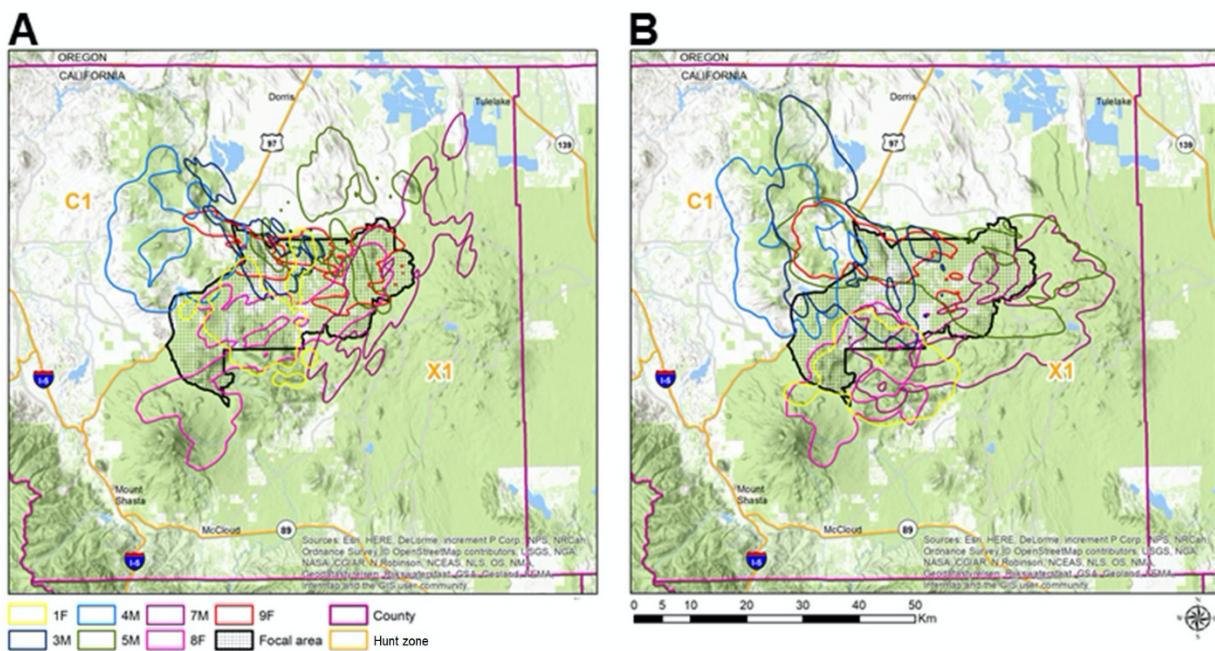


Fig. 15: Winter 2018-2019 (A) and summer 2018 (B) home ranges of GPS collared mountain lions that overlapped a focal area used for mountain lion density estimation in Siskiyou County. Unique identities of individual mountain lions are coded alphanumerically. F – Female, M – Male.

MOUNTAIN LION DIET COMPOSITION

Over the duration of the study, we investigated a total of 1516 GPS clusters to identify prey species killed by mountain lions. We were able to confirm the remains of 486 prey individuals at 444 clusters (Table A3). Deer were the most common prey species of mountain lions ($n = 367$). Other ungulate species killed by mountain lions included elk ($n = 18$), pronghorn ($n = 1$) and feral horse ($n = 1$). Remains of cattle were found at 2 clusters, both confirmed scavenging events. We also found carcasses of 39 other mammals and remains of 58 birds at mountain lion clusters we investigated (Fig. 16). Video recordings at a subset of kill sites indicated that birds may be predominantly chased and killed while mountain lions feed on carcasses of larger prey species they killed. Most clusters had one carcass, but 37 clusters had > 1 carcass. When two ungulate carcasses were present, these were two deer individuals ($n_{clusters} = 10$), one deer and one elk ($n_{clusters} = 1$), or two elk ($n_{clusters} = 1$). Clusters that had one ungulate and another carcass contained deer and bird ($n_{clusters} = 14$), deer and small carnivore ($n_{clusters} = 2$), and deer and unknown mammal ($n_{clusters} = 1$). Five clusters had three carcasses, which were one deer and two birds ($n_{clusters} = 3$), two deer and one bird ($n_{clusters} = 1$), and two small mammals and one bird ($n_{clusters} = 1$).

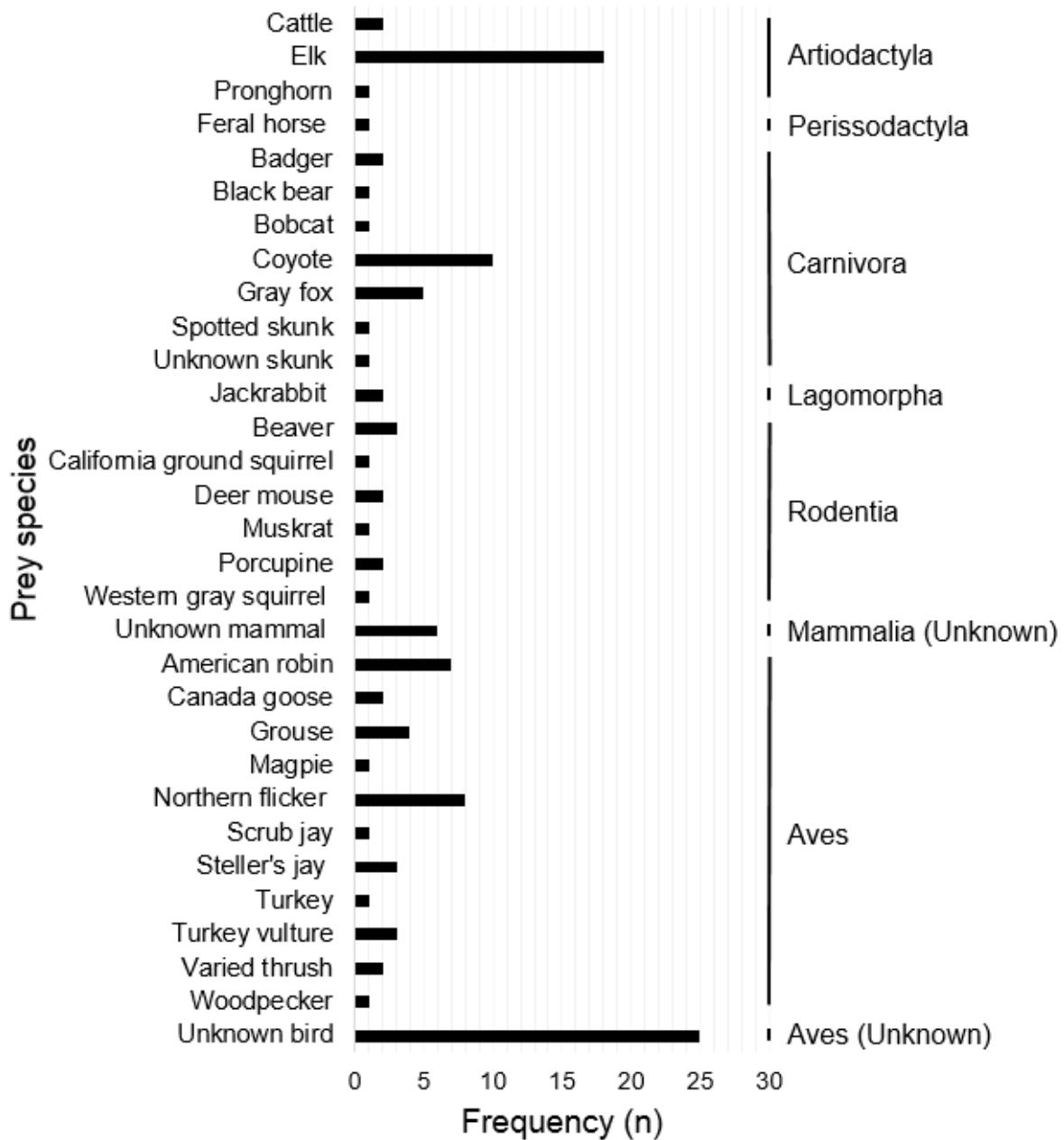


Fig. 16. The frequency of occurrence for species other than mule deer that were present at mountain lion GPS location clusters visited on the Siskiyou project, Feb 2017 - Feb 2020.

We were able to assign age class information (fawns, yearling, or adults) for 323 of the deer found at mountain lion location clusters, of which 97% ($n = 313$) were predation and 10 (3%) were confirmed scavenging events. Based on this information, fawns ($n = 101$) accounted for approximately 31%, yearlings ($n = 17$) accounted for 5%, and adults ($n = 205$) accounted for 64% of deer found at clusters (Fig 17).

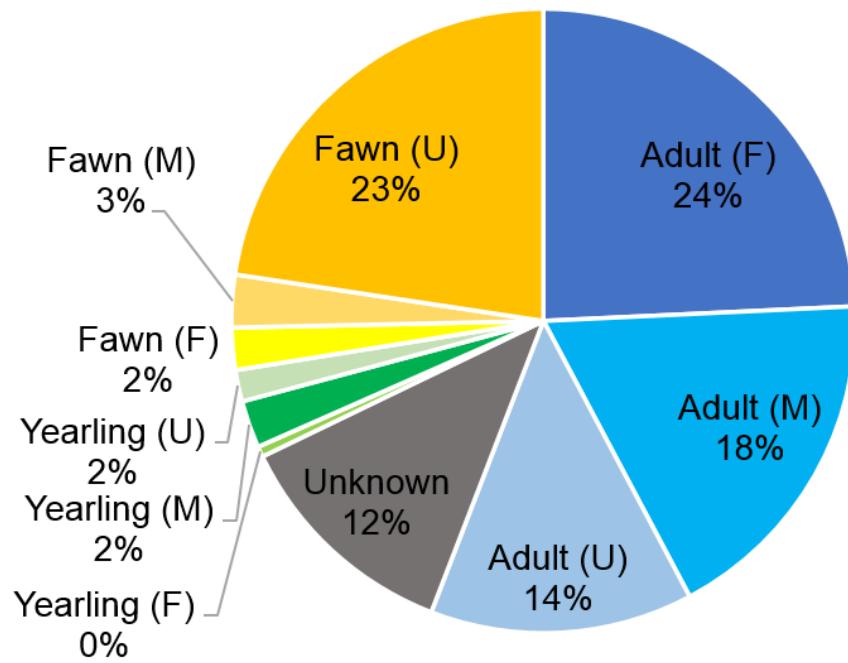


Fig. 17. Age and sex composition of mule deer consumed by mountain lions on the Siskiyou project, Feb 2017 - Feb 2020. F - Female, M - Male, U - Unknown.

More detailed age information based on cementum annuli was available for 162 deer tooth samples we collected at clusters. We summarize the age structure of 126 adult deer of known sex consumed by mountain lions in Fig. 18. Three yearlings are excluded from the age structure delineation below and one tooth sample was not ageable due to broken structure. Based on these results, the majority of adult deer killed by mountain lions were prime aged individuals (2-7 years old). Approximately 23% of deer found at clusters can be considered senescent (≥ 8 years of age).

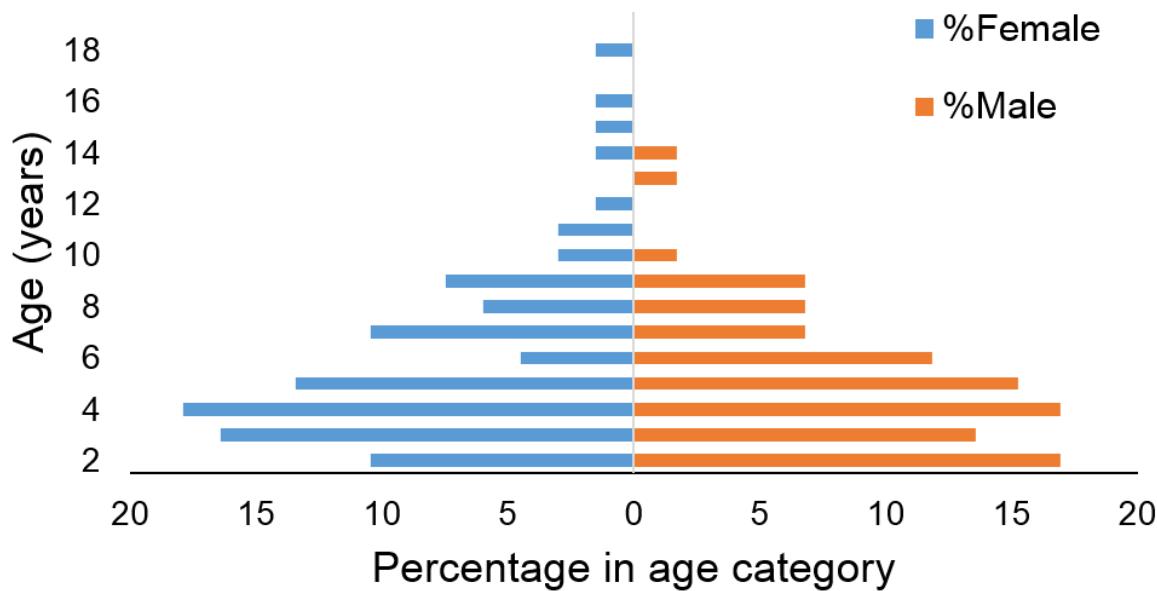


Fig. 18. Age structure of deer carcasses utilized by collared mountain lions on the Siskiyou project. The samples include 126 adult deer individuals ($n_{females} = 67$, $n_{males} = 59$).

MOUNTAIN LION KILL RATES

We were able to estimate ungulate kill rates based on 20 intensive 4-week monitoring sessions during which we visited all mountain lion GPS location clusters (Table 6). Most sessions pertained to adult males ($n_{individuals} = 6$, $n_{sessions} = 10$) and adult females with kittens ($n_{individuals} = 3$, $n_{sessions} = 8$), with the fewest sessions for solitary adult females ($n_{individuals} = 1$, $n_{sessions} = 2$). During these sessions we found 129 prey items ($n_{deer} = 94$, $n_{elk} = 3$, $n_{other mammal} = 9$, $n_{bird} = 23$). We determined that one deer and one elk were scavenged, and these two items were not included in kill rate estimation.

Table 6: Mountain lion kill rate sampling sessions on the Siskiyou project. During these 4-week long intensive sessions, all GPS location clusters from collared focal mountain lions were field-visited.

Mountain lion ID	Reproductive status	Start date	End date	Season	Number of kills	Number of ungulate kills	Kill rate (ungulates/week)	Inter-kill interval (days)	Kill rate (kg/day)
1F	FK	15-Sep-17	12-Oct-17	Fall	3	3	0.75	6.71	4.79
	FK	17-Jan-18	13-Feb-18	Winter	4	3	0.75	10.86	6.25
3M	M	14-Oct-17	10-Nov-17	Fall	3	3	0.75	12.60	6.61
	M	17-Jan-18	13-Feb-18	Winter	4	3	0.75	7.25	6.71
4M	M	16-Feb-18	15-Mar-18	Spring	5	5	1.25	6.24	8.86
	M	4-Oct-18	31-Oct-18	Fall	7	6	1.50	4.63	12.04
5M	M	3-Jul-18	30-Jul-18	Summer	4	1	0.25	NA	6.39
	M	19-Nov-18	16-Dec-18	Winter	3	3	0.75	10.17	11.96
7M	M	16-Apr-18	13-May-18	Spring	4	3	0.75	8.97	6.96
	FK	16-Feb-18	15-Mar-18	Spring	6	5	1.25	5.77	9.64
8F	FK	3-Jul-18	30-Jul-18	Summer	17	10	2.50	2.44	16.57
	FK	19-Nov-18	16-Dec-18	Winter	8	7	1.75	4.42	15.11
9F	F	9-Apr-18	6-May-18	Spring	6	2	0.50	8.92	3.61
	F	19-Nov-18	16-Dec-18	Winter	4	3	0.75	8.04	5.39
12M	M	1-Apr-19	28-Apr-19	Spring	8	2	0.50	18.83	3.25
	M	20-Aug-19	16-Sep-19	Fall	7	7	1.75	3.69	14.04
13F	FK	1-Apr-19	28-Apr-19	Spring	10	9	2.25	2.83	19.25
	FK	12-Aug-19	8-Sep-19	Summer	15	12	3.00	2.32	17.36
14M	FK	6-Jan-20	2-Feb-20	Winter	7	6	1.50	4.97	15.00
	M	26-Aug-19	22-Sep-19	Fall	2	2	0.50	13.59	5.36

Kill rates expressed as number of ungulates killed/week were highest for adult females with kittens ($\bar{x} = 1.72$, range = 0.75-3.00), intermediate for adult males ($\bar{x} = 0.88$, range = 0.25-1.75), and lowest for one solitary adult female ($\bar{x} = 0.63$, range = 0.50-0.75). Inter-kill intervals between ungulate kills were shortest for adult females with kittens ($\bar{x} = 5.04$ days, range = 2.32-10.86), intermediate for the solitary adult female ($\bar{x} = 8.48$ days, range = 8.04-8.92), and longest for adult males ($\bar{x} = 9.55$ days, range = 3.69-18.83; calculation excludes one kill rate session during which only one ungulate was killed).

Adult females with kittens killed the largest biomass of ungulates in kg/day ($\bar{x} = 13.00$, range = 4.79-19.25), followed by adult males ($\bar{x} = 8.22$, range = 3.25-14.04), and the solitary adult female ($\bar{x} = 4.50$, range = 3.61-5.39).

Kill rates (ungulates/week) were highly consistent across spring (1.08 ± 0.66), fall (1.05 ± 0.54), and winter (1.04 ± 0.46). The mean summer kill rate was substantially higher but also showed the greatest variability (1.92 ± 1.46) (Fig. 18A). Similarly, kill rates (biomass) were relatively consistent across spring (8.60 ± 5.84), fall (8.59 ± 4.19), and winter (10.07 ± 4.49), but higher and more variable in summer (13.44 ± 6.12) (Fig. 18B).

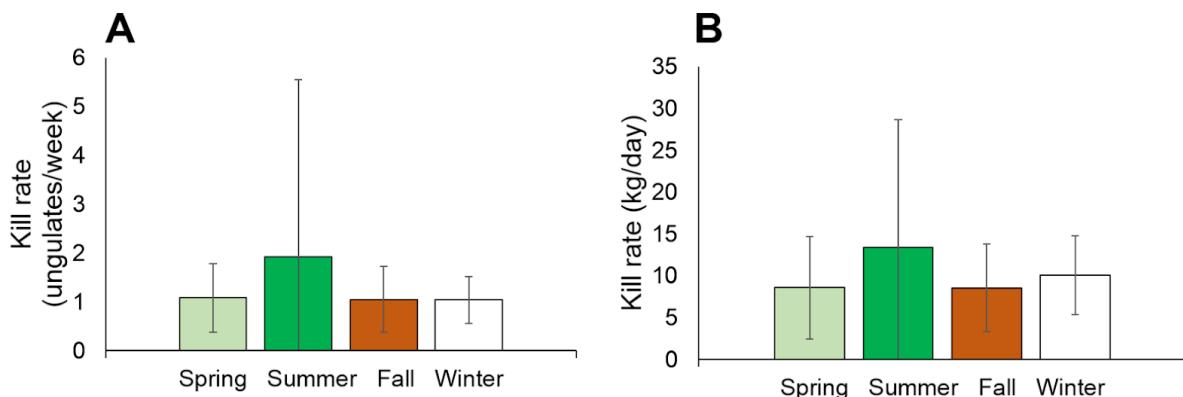


Fig. 18. Seasonal kill rate frequency (A) and biomass (B) of ungulates killed by mountain lions on the Siskiyou project. Data are based on 20 empirical kill rate sessions that involved visiting all location clusters of focal collared mountain lions in 28-day periods ($n_{\text{spring}} = 6$, $n_{\text{summer}} = 3$, $n_{\text{fall}} = 5$, $n_{\text{winter}} = 6$). Error bars are $\pm 95\%$ confidence intervals.

EFFECT OF SCAVENGERS ON MOUNTAIN LION KILL RATES

We obtained data from 110 deployments of video cameras at carcass locations that we identified based on GPS location clusters from collared mountain lions. We summarize herein video data from 77 deployments that were reviewed and tagged to date.

We visited fresh clusters promptly for camera deployment (1.99 ± 1.26 days from the cluster initiation). Based on field evidence, bears had already visited the carcasses at 4

locations prior to our camera deployments, and once deployed the cameras detected bears at all these 4 sites. Overall, we detected bears at 37 deployments (48%).

At 16 locations (21%), the cameras malfunctioned prior to our targeted full 3 weeks of monitoring. Based on the 61 deployments that were active for 3 weeks, carcasses monitored during the summer period had the highest visitation rate by bears (75%), followed by fall (69%), spring (46%), and winter (19%). Bears arrived on average 10.06 ± 6.43 days after the initiation of the cluster by the mountain lion, but this is an overestimate because the 4 camera deployments for which we found bear sign upon site investigation could not be included in the estimation due to various times elapsed between cluster initiation and visitation by field crews.

Of the 61 deployments active for 3 weeks, 49 involved ungulates with an initial weight ≥ 40 kg and we estimated feeding times of mountain lions based on video data for this subset. Feeding times of mountain lions were shorter for carcasses visited by bears within < 96 hours from cluster initiation ($1039\text{ s} \pm 1375\text{ SD}$, $n = 8$) than for carcasses at which bears arrived after > 96 hours from cluster initiation or not at all ($2370\text{ s} \pm 2624\text{ SD}$, $n = 41$).

DISCUSSION

Results from our matrix model using vital rates estimated from our sample of telemetered fawns ($n = 141$ over 3 years) and adult female deer ($n = 81$ over 5.25 years) indicate that deer across our study area likely increased over the course of our study. While there was substantial uncertainty, the average estimate of lambda indicates an approximately 3% annual increase of the population (lambda = 1.027). Compared to studies conducted across the range of deer, our estimates of adult survival were similar to the overall average reported for the species (0.84; Forrester & Wittmer 2013) and showed little variability among years. Estimates of reproductive rates (pregnancy and number of fetuses) were at the higher end of those typically reported for the species (Forrester & Wittmer 2013) and resembled those reported for deer populations also thought to be increasing (e.g., Monteith et al. 2014). Fawn survival over our 3-year monitoring period was slightly higher than the average for the species and, as expected, showed the greatest among-year variability (Forrester & Wittmer 2013).

Estimates of deer population density on both summer and winter ranges fall within densities reported for California (Furnas & Landers unpublished data). There is currently little indication deer are at their ecological carrying capacity across the study area. First, with the exception of March 2015, BCS collected during captures including in winter 2018 indicated that female deer were slightly above average in terms of body condition. While the lowest observed annual adult survival rate coincided with low BCS of deer during capture (i.e., 2015/16), we caution against overinterpreting the lower body conditions in 2015 as assessment methods differed from those used during the remainder of the project. Second, high observed reproductive rates point towards limiting factors other than nutrition as food limited cervids tend to experience reduced

reproductive rates first (Gaillard et al. 2000). Third, we did not find evidence of starvation in either fawns or adult females when investigating causes of mortality in the field including in winter. Finally, during our vegetation surveys we found no evidence of browse damage, particularly on summer range, typical for food limited populations. Rather, we found summer (e.g., Fons Butte, Buck Mountain) and winter (e.g., Day Bench, Tionesta, Mount Hebron) ranges with high shrub cover that provided deer year-round access to both abundant and high-quality forage. Water availability during summer, however, may be of some concern and require future investigation.

Specifically, a preliminary investigation into space use patterns in summer indicated larger home ranges than those reported for black-tailed deer in areas in California closer to the coast (Forrester et al. 2015, Bose et al. 2017) and short-term exploratory movements that might be related to water access.

There is currently no indication that deer in our study area experiences a significantly biased sex ratio of adults that has been hypothesized to cause a decline in reproductive potential across many species (reviewed in Ancona et al. 2017). Specifically, the doe:buck ratio of approximately 2.16:1 on winter range where mating likely occurs is comparable to other mule and black-tailed deer populations (e.g., White et al. 2001) and appears typical for polygynous ungulates where males often experience higher adult mortality from predation than females (Berger & Gompper 1999). In our study system, predation by mountain lions involved higher proportion of adult female than adult male deer, but selective removal of males occurred annually through legal hunting that was restricted to males. Pregnancy rates were also high (average of almost 95% based on 31 females examined in 2 different years) and we did not find evidence of an extended fawning period that would suggest a negative effect of delayed conception dates. While we ended fawn capture efforts in early July, we did not find evidence for many newborn fawns as had been suggested until daily monitoring ended in September.

Unsurprisingly, given the same guild of known deer predators occurred in our study area as in other areas of California where telemetered fawns were monitored (e.g., Monteith et al. 2014, Forrester & Wittmer 2019), predation was the most frequent cause of mortality of fawns. Depending on the assigned confidence during mortality site investigations, predation accounted for 38-77% of fawn mortalities. As in previous studies in California (e.g., Forrester & Wittmer 2019), coyotes and black bears were the two most significant fawn predators. While there was still a peak in fawn mortalities attributed to predation in the months immediately following birth, the slightly higher predation from coyotes resulted in a more evenly spread mortality risk of fawns across the year. Interestingly, the combined effect of predation from mountain lions and bobcats was slightly higher than that from either coyotes or black bears. This is primarily due to mountain lion predation on fawns throughout the year but may also reflect our ability to correctly identify predator species at mortality sites that had still been undisturbed by known scavengers such as black bears. The higher observed rates of fawn survival from winter onwards (i.e., fawns 7-12 months of age) further confirms our previous suggestion that food limitation or adverse weather are currently not considered as limiting factors including of fawns.

Predation was also the most common cause of adult mortality. Depending on the assigned confidence during mortality site investigations, predation accounted for 32–70% of adult mortalities we recorded. Mountain lions were the most common predator of collared adult females. Coyotes were also an important predator of adult deer, a result not previously observed in California. For example, a study conducted in the Mendocino National Forest with similar duration and sample sizes did not report any adult mortality from coyotes (Wittmer et al. 2014). The overall impact of predation on deer population dynamics, particularly from mountain lions, will be discussed further below.

It is noteworthy that we recorded several instances of road mortalities of fawns ($n = 3$) as well as yearlings and adult deer. The impact of roads was likely higher than our results indicated for several reasons. First, we focused fawn capture efforts on areas that did not have major roads nor received significant traffic volume. Second, a total of 3 of our marked fawns were reported killed on roads as yearlings/adults after their monitoring had ended. Given the majority of deer we monitored were migratory, mitigating the effect of road mortalities might be a promising management strategy to further improve deer population health in the study area both via increased recruitment and adult survival. A variety of methods in addition to GPS location data used here could be used to determine possible hotspots for deer crossing roads including direct observation of roadkills recorded by the Department of Transportation or citizen science lead initiatives. Many other species will likely benefit from attempts to mitigate the effect of roads including wide ranging carnivores such as mountain lions, two of which also died from vehicle/train collisions.

While predation was the most common mortality cause across deer age-classes, the deer population was able to increase nevertheless. The effect of mountain lions on deer needs to be evaluated in the context of the high human-caused mortality of mountain lions, particularly from poaching pressure. A total of 3 of the 14 mountain lions (21%) we monitored were illegally killed over the duration of our study. Thus, the poaching impact on mountain lions was likely representative of a light to moderately hunted mountain lion population in areas in the USA where puma hunting is still legal.

Simultaneously collected data on mountain lion diet confirmed the importance of deer as mountain lion prey. Of the 444 clusters with carcasses, 83% contained deer. While elk contributed to the diet of mountain lions, only select adult males killed elk and those that did disproportionately killed calves (56%) and yearlings (28%). The availability of a second ungulate as prey for mountain lions may have slightly reduced their impact on deer (Marescot et al. 2015).

Mountain lion kill rates, expressed as the number of ungulates killed per week, were highest for adult females with kittens, intermediate for adult males, and lowest for the 1 solitary female we intensively monitored for two 4-week kill rate sessions. While our estimated kill rates for females with kittens were higher than averages reported for mountain lions across their range, the difference was not significant (Cristescu et al. 2020). Kill rates of all age classes were also lower than those reported for the Mendocino National Forest where mountain lions experienced high rates of

kleptoparasitism from black bears (Allen et al. 2015b). When we converted kill rates into biomass of ungulates killed in kg/day, estimates for females with kittens were again slightly higher than the overall average across all mountain lion studies but did not differ significantly. Biomass of ungulates killed in kg/day were lower for both adult males and solitary females. This is likely a consequence of the reliance of mountain lions on deer in our study despite the availability, albeit patchy, of elk as well as the large number of fawns killed (31% of deer with known age were fawns). Previous research has suggested that mountain lions may preferentially kill fawns as a strategy to avoid kleptoparasitism from black bears (Clark et al. 2014), but an alternative explanation is that fawns are more vulnerable to predation due to poorer anti-predator strategies compared to adults.

Densities of mountain lions were lower and home ranges larger than in comparable environments nearby (e.g., Allen et al. 2015b). This is possibly in part a product of prey availability, as adult female mule deer in Siskiyou had larger home ranges than black-tailed deer in the Mendocino National Forest (Bose et al. 2017), and deer densities were lower in Siskiyou than in Mendocino (Lounsberry et al. 2014). In addition, mountain lion in our system appeared “partially migratory” with some residents not following the deer migrations we recorded. This is also different from other populations in California where mountain lion movements closely followed those of deer (Allen et al. 2014, Cristescu et al. 2019). However, poaching and other human caused mortalities, such as documented in association with linear transportation infrastructure, certainly played a role in the lower mountain lion density we recorded in Siskiyou. Indeed, human caused mortalities were documented throughout the project, including during the monitoring period for density estimation, when 2 of the 7 mountain lions monitored died in winter 2018-2019 as a result of poaching and a train accident, respectively. The mountain lion population in the X1 deer hunt zone is connected to Oregon via the C1 deer hunt zone, as evidenced by movements of collared individuals, including the dispersal of one male from Siskiyou to southern Oregon. Given the different mountain lion management regime in Oregon compared to California, this could possibly influence mountain lion densities in Siskiyou and such dynamics would need further study.

Black bears visited approximately half of the ungulate carcasses that resulted from mountain lion predation. Unlike another California study system (Mendocino National Forest), bears generally did not detect the carcasses promptly, which frequently allowed mountain lions to feed several nights. Those carcasses that did experience rapid visitation by bears were typically abandoned by mountain lions and were associated with decreased overall feeding times by the lions. Some bears were active in all seasons including winter, with one winter range (Day Bench) having remarkably high activity by bears, possibly due to milder weather conditions. Mountain lion kill rates were the highest in summer, when carcass detection by bears was also greatest, likely due to increased olfactory cues at high temperatures and with decomposition. However, we cannot unequivocally posit that interference by bears increased mountain lion kill rates on ungulates, as the summer kill rate estimate had the greatest variability of all seasons. While bears affected mountain lion kill rates to some extent, these dominant scavengers had less pronounced effects on mountain lion feeding ecology in Siskiyou,

and more diffuse impact on ungulates, than those documented in other study systems (Elbroch et al. 2015).

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Table A1: Capture and monitoring information of 145 deer caught as fawns as part of the Siskiyou deer-mountain lion study between 2016-2020. Note that monitoring continued for surviving fawns until 31 May of second year of monitoring when yearlings transitioned into the adult age class. Status updated until 30 June 2020 when monitoring ended.

No	ID	Fawning area	Capture date	Sex	Weight (kg)	Hoof growth (mm)	Camera trap nights ¹	Date last observed alive or dead ³	Status at end of monitoring and cause of mortality
2016									
1	Z001	Buck Mountain	14-Jun-16	Female	2.35	2.50	NA	10-Oct-16	Dead; Predation (Coyote)
2	Z002	Fons Butte	23-Jun-16	Female	4.65	3.00	NA	31-May-18	Alive
3	Z003	Fons Butte	23-Jun-16	Male	2.35	3.00	NA	26-Nov-16	Unknown
4	Z004	Buck Mountain	23-Jun-16	Male	5.20	NR	NA	25-Jun-16	Dead; Predation (Bear)
2017									
5	Y001	Fons Butte	4-Jun-17	Female	2.30	3.00	122	27-Apr-18	Dead; Roadkill
6	Y011	Asperin Butte	4-Jun-17	Female	3.50	3.00	121	4-Jun-17	Dead; Predation (Unknown)
7	Y012	Fons Butte	4-Jun-17	Male	3.85	2.40	122	8-Jun-17	Dead; Predation (Unknown)
8	Y002	Fons Butte	5-Jun-17	Male	5.45	3.50	121	1-Jul-17	Dead; Predation (Coyote)
9	Y013	Fons Butte	6-Jun-17	Male	4.70	3.00	120	9-Jul-17	Dead; Predation (Puma)
10	Y003	Fons Butte	8-Jun-17	Male	3.20	3.00	100	22-Dec-18	Dead; Predation (Puma)
11	Y006	Buck Mountain	8-Jun-17	Female	4.30	3.00	116	15-Dec-17	Dead; Unknown
12	Y007	Buck Mountain	8-Jun-17	Male	4.80	3.50	NA ²	24-Jan-19	Dead; Predation (Unknown)
13	Y004	Asperin Butte	9-Jun-17	Female	6.00	4.25	116	12-Jun-17	Dead; Unknown
14	Y016	Buck Mountain	10-Jun-17	Female	2.80	2.75	NA ²	12-Jun-17	Dead; Predation (Bear)
15	Y005	Buck Mountain	10-Jun-17	Male	3.20	3.00	79	4-Aug-17	Dead; Predation (Coyote)
16	Y009	Asperin Butte	11-Jun-17	Male	6.30	3.85	115	11-Jun-17	Dead; Predation (Coyote)
17	Y019	Buck Mountain	13-Jun-17	Female	3.35	2.50	111	18-Feb-18	Dead; Unknown
18	Y014	Fons Butte	14-Jun-17	Male	5.00	4.00	112	3-Apr-19	Unknown
19	Y010	Red Hill	18-Jun-17	Female	3.50	3.80	107	20-Jun-17	Unknown

20	Y015	Buck Mountain	18-Jun-17	Male	4.10	4.00	70	26-Jun-17	Dead; Predation (Coyote)
21	Y017	Buck Mountain	19-Jun-17	Female	4.30	4.00	105	23-Jul-17	Dead; Predation (Coyote)
22	Y024	Buck Mountain	19-Jun-17	Male	6.20	3.50	105	31-May-19	Alive ⁴
23	Y029	Buck Mountain	21-Jun-17	Male	3.20	NR	47	26-Jun-17	Dead; Predation (Bear)
24	Y023	Buck Mountain	21-Jun-17	Female	5.70	3.00	104	4-Dec-17	Dead; Predation (Puma)
25	Y034	Fons Butte	21-Jun-17	Male	5.60	2.50	105	13-Apr-18	Dead; Predation (Puma)
26	Y032	Buck Mountain	22-Jun-17	Female	4.40	3.00	102	8-Nov-17	Unknown, dropped collar
27	Y025	Fons Butte	22-Jun-17	Female	2.70	2.50	103	24-Mar-18	Unknown, dropped collar
28	Y021	Fons Butte	23-Jun-17	Male	3.90	3.00	103	11-Dec-18	Unknown, dropped collar ⁵
29	Y026	Fons Butte	24-Jun-17	Male	5.70	3.00	101	13-Nov-18	Unknown, dropped collar
30	Y030	Buck Mountain	25-Jun-17	Male	5.10	4.10	100	29-Oct-17	Unknown
31	Y046	Buck Mountain	25-Jun-17	Female	6.45	6.40	100	22-Nov-17	Unknown
32	Y039	Buck Mountain	25-Jun-17	Male	3.90	2.20	99	27-Jun-17	Dead; Predation (Bobcat)
33	Y028	Red Hill	26-Jun-17	Male	4.50	3.10	98	3-Apr-18	Dead; Predation (Puma)
34	Y018	Fons Butte	26-Jun-17	Female	7.20	7.00	101	27-Jun-17	Dead; Predation (Bobcat)
35	Y031	Buck Mountain	27-Jun-17	Male	7.70	NR	97	1-Dec-17	Dead; Unknown
36	Y027	Buck Mountain	27-Jun-17	Male	7.40	3.50	NA ²	17-Apr-19	Unknown ⁴
37	Y035	Buck Mountain	28-Jun-17	Female	6.10	4.50	NA ²	10-Jul-17	Dead; Unknown
38	Y040	Buck Mountain	28-Jun-17	Male	5.50	3.00	73	29-Jun-17	Dead; Predation (Bear)
39	Y038	Fons Butte	29-Jun-17	Male	7.60	4.00	96	18-Jan-18	Dead; Predation (Coyote)
40	Y042	Fons Butte	1-Jul-17	Male	7.50	3.75	95	19-Nov-17	Dead; Predation (Puma)
41	Y043	Buck Mountain	2-Jul-17	Male	6.30	3.00	93	31-May-19	Alive
42	Y020	Buck Mountain	4-Jul-17	Male	7.10	6.05	92	18-Jul-17	Dead; Predation (Coyote)

2018

43	R061	Fons Butte	7-Jun-18	Female	3.00	3.90	118	7-Jun-18	Dead; Predation (Coyote)
44	R062	Fons Butte	7-Jun-18	Female	3.30	1.50	117	24-Aug-18	Unknown
45	R067	Fons Butte	7-Jun-18	Male	3.30	3.00	117	17-Jun-18	Dead; Predation (Bear)

46	R059	Trout Camp	8-Jun-18	Female	3.50	2.00	117	17-Jul-18	Dead; Natural (<i>stuck in logs</i>)
47	R066	Trout Camp	9-Jun-18	Male	4.20	2.00	NA ²	22-Jun-18	Dead; Predation (Coyote)
48	R072	Asperin Butte	13-Jun-18	Male	3.30	2.50	111	5-Aug-18	Dead; Roadkill
49	R071	Fons Butte	13-Jun-18	Female	3.10	2.50	112	12-Sep-18	Dead; Predation (Puma)
50	R058	Trout Camp	14-Jun-18	Female	3.80	4.50	99	7-Aug-18	Dead; Predation (Coyote)
51	R056	Fons Butte	14-Jun-18	Female	3.70	3.10	110	16-Jun-18	Dead; Predation (Bear)
52	R068	Trout Camp	14-Jun-18	Female	4.60	2.00	111	31-Mar-19	Dead; Roadkill
53	R075	Trout Camp	14-Jun-18	Female	4.70	2.50	110	19-Nov-18	Dead; Unknown
54	R060	Buck Mountain	15-Jun-18	Male	3.50	3.00	110	17-Jul-18	Dead; Predation (Bobcat)
55	R057	Fons Butte	15-Jun-18	Male	3.20	3.00	110	24-Jan-19	Dead; Predation (Unknown)
56	R065	Fons Butte	16-Jun-18	Female	6.20	4.00	109	27-Jun-18	Dead; Predation (Bear)
57	R084	Fons Butte	16-Jun-18	Female	5.40	3.00	108	20-Nov-19	Unknown
58	R074	Trout Camp	17-Jun-18	Female	4.10	2.70	108	3-Oct-18	Dead; Predation (Unknown)
59	R078	Fons Butte	18-Jun-18	Male	6.10	3.00	84	21-Sep-19	Unknown, dropped collar
60	R077	Buck Mountain	18-Jun-18	Male	5.90	2.00	106	8-Oct-19	Unknown
61	R076	Fons Butte	18-Jun-18	Female	3.50	2.50	NA ²	10-Jan-19	Dead; Predation (Coyote)
62	R070	Trout Camp	19-Jun-18	Male	4.40	3.00	107	17-Aug-18	Dead; Unknown
63	R069	Trout Camp	19-Jun-18	Female	4.50	1.50	85	8-Nov-18	Dead; Predation (Coyote)
64	R092	Buck Mountain	20-Jun-18	Male	6.40	6.00	105	3-Aug-18	Dead; Natural (punctured lung)
65	R081	Buck Mountain	20-Jun-18	Male	3.60	2.80	83	25-Aug-18	Dead; Predation (Bobcat)
66	R091	Asperin Butte	20-Jun-18	Female	2.70	3.00	81	31-Oct-18	Dead; Predation (Puma)
67	R073	Fons Butte	20-Jun-18	Female	3.60	2.50	105	18-Dec-18	Unknown
68	R083	Asperin Butte	20-Jun-18	Male	4.50	3.50	105	10-Jul-18	Dead; Predation (Coyote)
69	R088	Trout Camp	20-Jun-18	Male	6.50	3.00	105	21-Aug-18	Dead; Predation (Coyote)
70	R094	Buck Mountain	20-Jun-18	Female	5.90	4.00	104	31-Jul-18	Dead; Predation (Puma)
71	R085	Buck Mountain	21-Jun-18	Male	5.10	5.00	103	14-Jul-18	Dead; Predation (Puma)
72	R090	Asperin Butte	21-Jun-18	Male	3.90	2.20	104	31-Aug-18	Dead; Unknown

73	R098	Trout Camp	21-Jun-18	Female	3.30	2.75	83	10-Sep-18	Dead; <i>Predation (Coyote)</i>
74	R099	Buck Mountain	22-Jun-18	Male	3.20	2.00	103	5-Sep-19	Unknown
75	R097	Trout Camp	22-Jun-18	Female	5.70	2.00	104	12-Sep-19	Unknown
76	R082	Trout Camp	22-Jun-18	Female	4.80	3.00	103	29-Mar-19	Dead; <i>Unknown</i>
77	R089	Asperin Butte	22-Jun-18	Male	7.30	3.50	79	10-Oct-18	Dead; <i>Predation (Coyote)</i>
78	R103	Asperin Butte	23-Jun-18	Female	6.40	3.00	75	13-Mar-19	Unknown, dropped collar
79	R102	Trout Camp	23-Jun-18	Male	7.10	3.50	103	24-Jun-18	Dead; <i>Predation (Bobcat)</i>
80	R100	Trout Camp	23-Jun-18	Male	3.00	1.50	77	24-Nov-18	Unknown
81	R109	Buck Mountain	24-Jun-18	Male	8.90	3.50	77	15-Feb-19	Unknown
82	R093	Buck Mountain	24-Jun-18	Male	7.90	NR	100	27-Jul-18	Unknown, dropped collar
83	R080	Fons Butte	24-Jun-18	Male	2.80	2.00	102	1-Aug-18	Dead; <i>Predation (Coyote)</i>
84	R086	Trout Camp	24-Jun-18	Female	3.70	2.00	100	4-Jul-18	Dead; <i>Predation (Unknown)</i>
85	R095	Asperin Butte	24-Jun-18	Male	5.20	3.10	NA ²	1-Oct-18	Dead; <i>Unknown</i>
86	R063	Fons Butte	25-Jun-18	Male	4.40	4.00	98	27-Jun-18	Dead; <i>Predation (Bear)</i>
87	R104	Fons Butte	25-Jun-18	Female	4.70	4.00	100	1-Oct-18	Dead; <i>Unknown</i>
88	R079	Asperin Butte	26-Jun-18	Female	4.20	1.90	99	25-Nov-18	Dead; <i>Unknown</i>
89	R087	Asperin Butte	27-Jun-18	Female	4.90	4.00	97	18-Dec-19	Unknown
90	R108	Fons Butte	27-Jun-18	Female	5.70	2.00	97	11-Apr-19	Unknown
91	R107	Fons Butte	28-Jun-18	Female	4.10	3.00	97	28-Jun-18	Unknown
92	R110	Fons Butte	28-Jun-18	Female	8.00	NR	96	24-Oct-18	Dead; <i>Predation (Unknown)</i>
93	R064	Asperin Butte	28-Jun-18	Male	5.10	3.00	96	8-Sep-18	Dead; <i>Unknown</i>

2019

94	W116	Fons Butte	5-Jun-19	Male	2.70	4.00	117	23-Sep-19	Dead; <i>Predation (Puma)</i>
95	W127	Trout Camp	6-Jun-19	Male	3.20	2.30	114	28-Jul-19	Dead; <i>Predation (Coyote)</i>
96	W115	Trout Camp	9-Jun-19	Female	4.00	3.00	112	1-Mar-20	Unknown
97	W133	Trout Camp	9-Jun-19	Male	5.60	2.50	111	17-Jun-19	Dead; <i>Predation (Unknown)</i>
98	W112	Fons Butte	11-Jun-19	Female	2.80	2.00	105	21-Jun-19	Dead; <i>Predation (Bear)</i>

99	W117	Buck Mountain	11-Jun-19	Male	2.80	3.00	111	21-Jun-19	Dead; Predation (<i>Bobcat</i>)
100	W119	Fons Butte	11-Jun-19	Female	2.40	2.50	NA ²	16-Aug-19	Unknown
101	W114	Fons Butte	12-Jun-19	Male	3.00	3.50	110	15-Jun-19	Dead; Predation (<i>Bear</i>)
102	W123	Fons Butte	13-Jun-19	Female	3.70	3.20	103	17-Jun-20	Alive
103	W132	Trout Camp	13-Jun-19	Male	3.60	2.50	108	23-Jun-19	Dead; Predation (<i>Bear</i>)
104	W124	Fons Butte	14-Jun-19	Male	3.70	3.50	108	13-Mar-20	Unknown
105	W129	Fons Butte	14-Jun-19	Male	3.10	3.10	NA ²	30-Jun-20	Alive
106	W134	Fons Butte	15-Jun-19	Female	6.50	6.00	67	12-Nov-19	Unknown, dropped collar
107	W135	Trout Camp	15-Jun-19	Female	3.70	2.00	106	16-Sep-19	Dead; Unknown
108	W125	Trout Camp	16-Jun-19	Female	4.10	3.00	104	4-Jun-20	Alive
109	W113	Trout Camp	17-Jun-19	Male	3.20	3.00	104	23-Jun-19	Dead; Predation (Unknown)
110	W126	Fons Butte	17-Jun-19	Male	4.50	2.00	104	27-Sep-19	Unknown
111	W128	Fons Butte	17-Jun-19	Female	6.00	4.00	105	30-Jun-20	Alive
112	W146	Trout Camp	17-Jun-19	Female	3.30	2.00	NA ²	29-Feb-20	Unknown
113	W165	Fons Butte	17-Jun-19	Female	4.00	2.00	NA ²	18-Jun-19	Dead; Predation (<i>Bear</i>)
114	W130	Fons Butte	18-Jun-19	Female	5.00	3.50	104	4-Jun-20	Alive
115	W147	Trout Camp	18-Jun-19	Male	4.60	4.50	104	18-Jun-19	Dead; Predation (<i>Coyote</i>)
116	W148	Fons Butte	18-Jun-19	Female	5.80	2.50	99	13-Jul-19	Dead; Predation (<i>Bobcat</i>)
117	W131	Fons Butte	19-Jun-19	Female	4.10	4.00	103	21-Jun-19	Dead; Predation (<i>Bear</i>)
118	W138	Buck Mountain	19-Jun-19	Male	4.80	3.00	101	9-Sep-19	Dead; Predation (<i>Bobcat</i>)
119	W143	Trout Camp	19-Jun-19	Female	2.90	4.90	103	20-Jun-19	Dead; Predation (<i>Bear</i>)
120	W152	Asperin Butte	19-Jun-19	Female	3.80	3.00	101	30-Jun-20	Alive
121	W149	Trout Camp	20-Jun-19	Male	4.20	3.00	102	27-Dec-19	Dead; Unknown
122	W160	Fons Butte	20-Jun-19	Male	5.10	3.30	102	17-Jun-20	Alive
123	W162	Fons Butte	20-Jun-19	Female	3.70	3.50	102	21-Dec-19	Dead; Predation (Unknown)
124	W120	Fons Butte	21-Jun-19	Female	3.60	4.00	95	16-Mar-20	Unknown
125	W142	Fons Butte	21-Jun-19	Male	5.80	NR	96	30-Jun-20	Alive

126	W145	Fons Butte	21-Jun-19	Male	4.20	3.00	NA ²	16-Mar-20	Unknown
127	W151	Fons Butte	21-Jun-19	Male	4.30	4.00	101	2-Oct-19	Unknown
128	W121	Fons Butte	22-Jun-19	Male	5.60	NR	100	25-Jun-19	Dead; <i>Predation (Bear)</i>
129	W122	Buck Mountain	22-Jun-19	Male	6.10	4.20	99	9-Jul-19	Dead; <i>Predation (Bear)</i>
130	W153	Trout Camp	23-Jun-19	Male	5.80	8.00	98	4-Jun-20	Alive
131	W161	Trout Camp	23-Jun-19	Female	6.30	4.00	97	15-Aug-19	Dead; Unknown
132	W167	Asperin Butte	23-Jun-19	Male	4.00	2.40	100	8-Aug-2019	Dead; <i>Predation (Puma)</i>
133	W144	Asperin Butte	24-Jun-19	Female	4.70	3.80	102	30-Jun-20	Alive
134	W150	Buck Mountain	24-Jun-19	Male	5.10	5.00	98	28-Jun-19	Dead; <i>Predation (Bear)</i>
135	W166	Buck Mountain	24-Jun-19	Male	4.90	6.00	NA ²	13-Oct-19	Dead; <i>Predation (Puma)</i>
136	W156	Buck Mountain	26-Jun-19	Male	3.10	3.00	96	26-Dec-19	Unknown, dropped collar
137	W157	Trout Camp	26-Jun-19	Female	8.50	4.10	94	30-Jun-20	Alive
138	W163	Buck Mountain	26-Jun-19	Male	5.60	4.00	95	30-Jun-20	Alive
139	W170	Buck Mountain	26-Jun-19	Female	6.30	4.00	97	30-Jun-20	Alive
140	W154	Fons Butte	27-Jun-19	Male	4.00	2.00	89	30-Dec-19	Dead; <i>Predation (Puma)</i>
141	W111	Buck Mountain	28-Jun-19	Male	8.80	NR	52	30-Jun-20	Alive
142	W137	Fons Butte	28-Jun-19	Female	4.10	3.00	89	30-Aug-19	Dead; <i>Predation (Bobcat)</i>
143	W164	Buck Mountain	28-Jun-19	Female	4.80	3.80	93	5-Sep-19	Unknown
144	W169	Buck Mountain	28-Jun-19	Female	8.10	NR	95	27-Nov-19	Dead; <i>Predation (Coyote)</i>
145	W140	Fons Butte	30-Jun-19	Male	4.30	2.00	92	21-Oct-19	Dead; <i>Predation (Puma)</i>

¹ Camera trap nights refer to number of 24-h periods during which cameras were active, with the purpose of cameras being to monitor predator occurrence in the vicinity of confirmed fawning sites.

² Twin fawn / Capture location within ~100 m of another fawn's capture site.

³ Estimated date of mortality half way between last date recorded alive and date first detected on mortality or evidence at mortality site.

⁴ Ear tagged male fawns reported legally harvested after monitoring ended.

⁵ Animal reported killed on road after monitoring ended.

Table A2: Capture and monitoring information of 86 adult female deer ≥ 2-years-old captured as part of the Siskiyou deer-mountain lion study (2015-2020).

No	Deer ID	Capture date	Age (est) ¹	Age (cementum) ²	Weight (lbs)	rBCS (1-5) ⁴	Last date observed alive	Date collar heard on mortality	Mortality date collar ⁵	Date mortality investigated	Number of GPS fixes ⁶	Status at end of monitoring and <i>cause of mortality</i>
1	101	17-Mar-15	6+	Sample lost	136.0	2	16-Mar-16	NA	16-Mar-16	NA	8706	Dropped collar
2	102	17-Mar-15	Adult	Not collected	129.4	1.5	5-Feb-20	NA	NA	NA	8732	Alive; GPS failed ⁷
3	103	17-Mar-15	Adult	Sample lost	140.8	1	15-Mar-16	NA	15-Mar-16	NA	8727	Dropped collar
4	104	17-Mar-15	Adult	Sample lost	151.4	2.5	9-Jun-17	9-Jun-17	9-Jun-17	10-Jun-17	8733	Dead; <i>Predation (Coyote)</i>
5	105	17-Mar-15	Adult	Sample lost	115.3	2	5-Feb-20	NA	NA	NA	8768	Alive; GPS failed ⁷
6	106	17-Mar-15	5	Sample lost	170.7	3	27-Dec-15	NA	NA	NA	5772	Unknown
7	107	17-Mar-15	8+	Not collected	143.0	2	24-June-15	Unknown	NA	NA	1745	Unknown; collar failed
8	108	17-Mar-15	Adult	Sample lost	150.0	1.5	25-Sep-15	Unknown	25-Sep-15	NA	4586	Dead; <i>Unknown</i>
9	109	18-Mar-15	Old	Not collected	145.2	0.5	7-Jan-16	Unknown	7-Jan-16	NA	7040	Unknown
10	110	18-Mar-15	Adult	Not collected	144.8	NR	21-Mar-15	Unknown	21-Mar-15	NA	53	Unknown
11	111	18-Mar-15	Adult	Sample lost	155.3	1.5	8-Jul-15	Unknown	8-Jul-15	NA	2622	Dead; <i>Unknown</i>
12	112	18-Mar-15	Adult	Sample lost	151.4	2	2-Jun-19	NA	NA	NA	8789	Unknown; collar failed
13	113	18-Mar-15	5-6	Sample lost	151.8	2	3-Jan-17	4-Jan-17	3-Jan-17	4-Jan-17	8696	Dead; <i>Predation (Puma)</i>
14	114	18-Mar-15	Adult	Sample lost	151.8	1	6-Apr-20	NA	NA	NA	8723	Alive; GPS failed ⁷
15	115	18-Mar-15	Adult	Sample lost	154.4	3	31-Oct-19	NA	NA	NA	8718	Alive; GPS failed ⁷
16	116	18-Mar-15	Adult	Sample lost	145.6	1	22-Apr-15	Unknown	22-Apr-15	20-Oct-16	208	Dead; <i>Unknown</i>

17	117	18-Mar-15	4	Sample lost	139.9	1	31-Oct-19	NA	NA	NA	8724	Alive, GPS failed ⁷
18	118	18-Mar-15	Adult	Sample lost	124.1	1.5	27-Aug-16	6-Sep-16	27-Aug-16	6-Sep-16	8743	Dead; <i>Predation (Puma)</i>
19	119	19-Mar-15	Adult	Sample lost	136.0	NR	23-Oct-17	NA	NA	NA	8753	Unknown; collar failed
20	120	19-Mar-15	6	Sample lost	143.9	1.5	24-Apr-15	NA	24-Apr-15	NA	860	Dead; <i>Unknown</i>
21	121	19-Mar-15	Young adult	Sample lost	129.8	1	21-Nov-16	NA	NA	NA	8658	Unknown; collar failed
22	122	19-Mar-15	5	Sample lost	131.6	0.5	27-Jan-20	NA	NA	NA	8700	Alive; GPS failed ⁷
23	123	19-Mar-15	4	Sample lost	162.8	2	27-Jan-20	NA	NA	NA	8707	Alive; GPS failed ⁷
24	124	19-Mar-15	4	Sample lost	143.4	1.5	23-Dec-15	Unknown	23-Dec-15	NA	6684	Dead; <i>Unknown</i>
25	125	19-Mar-15	3	Sample lost	142.6	1	13-Nov-17	NA	13-Nov-17	1-May-18	8701	Dead; <i>Unknown</i>
26	201	7-Jul-16	2	4 (4-5)	120.0 ³	4	6-Jul-17	NA	6-Jul-17	NA	8606	Dropped collar
27	202	15-Jul-16	4-5	8 (8-9)	144.0	2	13-Aug-16	28-Aug-16	13-Aug-16	28-Aug-16	676	Dead; <i>Predation (Puma)</i>
28	203	15-Jul-16	4	8	124.0	2	4-Oct-16	6-Oct-16	4-Oct-16	6-Oct-16	1899	Dead; <i>Unknown</i>
29	204	23-Aug-16	4	3 (3-4)	150.0	3	22-Aug-17	NA	22-Aug-17	NA	8690	Dropped collar
30	205 ⁸	23-Aug-16	5	4 (4-5)	119.0	2 (3)	2-Jul-19	NA	NA	16-Jul-19	15921	Dead; <i>Unknown</i>
31	206	24-Aug-16	Adult	9	130.0	3	23-Aug-17	NA	23-Aug-17	NA	0	Dropped collar; collar failed
32	207	24-Aug-16	4	3	122.8	2	23-Aug-17	NA	23-Aug-17	NA	8693	Dropped collar
33	208	24-Aug-16	NR	2	115.0	2	23-Aug-17	NA	23-Aug-17	NA	8702	Dropped collar
34	209	25-Aug-16	NR	6	145.0	4	24-Aug-17	NA	24-Aug-17	NA	8713	Dropped collar
35	210	25-Aug-16	3-4	6 (6-7)	130.0 ³	4	24-Aug-17	NA	24-Aug-17	NA	8705	Dropped collar

36	211 ⁸	25-Aug-16	NR	2 (2-3)	147 (2017)	3 (2)	9-Jul-19	NA	NA	NA	15303	Dropped collar
37	212	25-Aug-16	Adult	2	125.0	3	24-Aug-17	NA	24-Aug-17	NA	8696	Dropped collar
38	213	27-Aug-16	3	3	107.0	3	26-Aug-17	NA	26-Aug-17	NA	8709	Dropped collar
39	214	27-Aug-16	3	7 (6-7)	122.0	4	26-Aug-17	NA	26-Aug-17	NA	8700	Dropped collar
40	215	27-Aug-16	NR	4	105.0	3	26-Aug-17	NA	26-Aug-17	NA	8648	Dropped collar
41	216	25-Aug-16	5-6	5 (5-6)	150.0 ³	NR	NA	NA	NA	NA	NA	Capture mortality
42	217	25-Aug-16	2-3	3 (3-4)	120.0 ³	NR	NA	NA	NA	NA	NA	Capture mortality
43	301	25-Aug-17	3	Not collected	NR	2	21-Jun-19	NA	NA	NA	7721	Dropped collar
44	302	12-Sep-17	Adult	Not collected	136.0	3	9-Jul-19	NA	NA	NA	6778	Dropped collar
45	303	13-Sep-17	5	Not collected	NR	2	2-Oct-18	3-Oct-18	2-Oct-18	3-Oct-18	4552	Dead; <i>Predation (Coyote)</i>
46	304	21-Sep-17	Adult	Not collected	137.5	3	5-Feb-18	NA	5-Feb-18	6-Feb-18	1622	Dead; <i>Predation (Puma)</i>
47	305	25-Sep-17	Adult	Not collected	131.5	2	12-Aug-18	13-Aug-18	12-Aug-18	13-Aug-18	3795	Dead; <i>Predation (Puma)</i>
48	306	26-Sep-17	2.5	Not collected	91.3	2	3-Apr-19	NA	NA	NA	5923	Unknown; collar failed
49	307	27-Sep-17	4-5	Not collected	115.5	2	23-Jul-19	NA	23-Jul-19	NA	7506	Dropped collar
50	308	28-Sep-17	4-5	Not collected	130.9	4	25-Jul-19	NA	NA	NA	6713	Dropped collar
51	309	28-Sep-17	Adult	Not collected	147.4	3	25-Jul-19	NA	NA	NA	7484	Dropped collar
52	401	6-Mar-18	2	2	115.0	3	5-Feb-20	NA	NA	NA	282	Alive; GPS failed ⁷
53	402	6-Mar-18	3	1	120.0 ³	2	26-Jul-19	NA	NA	NA	572	Unknown; collar failed
54	403	6-Mar-18	2	2	109.0	3	8-Aug-19	NA	NA	NA	613	Unknown; collar failed

55	404	6-Mar-18	4	3	125.0	2	9-Jul-19	NA	NA	NA	746	Unknown; collar failed
56	405	6-Mar-18	3	4	120.0 ³	3	13-Jan-20	NA	NA	NA	863	Alive; collar failed ⁷
57	406	7-Mar-18	4	2	127.0 ³	3	31-Oct-19	NA	NA	NA	605	Alive; GPS failed ⁷
58	407	7-Mar-18	4	3	114.0	2	13-Mar-20	NA	NA	NA	187	Alive; GPS failed ⁷
59	408	7-Mar-18	3	3	130.0 ³	3	6-Nov-19	NA	NA	NA	671	Alive; GPS failed ⁷
60	409	7-Mar-18	15	10	135.0	2	8-Oct-18	7-Oct-18	8-Oct-18	9-Oct-18	418	Dead; <i>Predation (Coyote)</i>
61	410	8-Mar-18	3	3	105.0	2	22-Mar-18	NA	22-Mar-18	22-Mar-18	27	Dead; <i>Predation (Puma)</i>
62	411	8-Mar-18	4	2	120.0 ³	3	5-Feb-20	NA	NA	NA	712	Alive; GPS failed ⁷
63	412	8-Mar-18	2	3	115.0 ³	3	9-Dec-19	NA	NA	NA	775	Alive; GPS failed ⁷
64	413	8-Mar-18	3	1	86.2	4	30-May-19	NA	30-May-19	7-Jun-19	811	Dead; <i>Predation (Puma)</i>
65	414	8-Mar-18	10	11	120.0	2	24-May-19	NA	24-May-19	16-Jun-19	789	Dead; <i>Unknown</i>
66	415	8-Mar-18	6	9	125.0 ³	2	29-Feb-20	NA	NA	NA	797	Alive; GPS failed ⁷
67	416	9-Mar-18	5-6	Not Collected	120.8	2	NA	NA	NA	NA	NA	Capture mortality
68	417	14-Aug-18	Adult	7	134.9	3	25-Apr-19	NA	25-Apr-19	29-Apr-19	3067	Dead; <i>Malnutrition/Disease</i>
69	418	14-Aug-18	6	Not Collected	112.8	2	9-Jun-20	NA	9-Jun-20	NA	7888	Dropped collar
70	419	14-Aug-18	5	4	135.3	2	10-Jan-20	NA	NA	NA	6085	Unknown; collar failed
71	420	14-Aug-18	3-4	4	137.5	3	9-Jun-20	NA	9-Jun-20	NA	7912	Dropped collar
72	421	14-Aug-18	5	7	138.6	2	10-Jun-20	NA	10-Jun-20	NA	5794	Dropped collar
73	422	15-Aug-18	5+	3	101.0	2	21-May-19	NA	21-May-19	22-May-19	3325	Dead; <i>Predation (Puma)</i>

74	423	15-Aug-18	7	3	119.0	3	29-Nov-18	1-Dec-18	29-Nov-18	4-Dec-18	1254	Dead; Unknown
75	424	16-Aug-18	3	3	126.5	4	11-Jun-20	NA	11-Jun-20	NA	7904	Dropped collar
76	425	17-Aug-18	5	8	128.3	3	NA	NA	NA	NA	NA	Capture mortality
77	426	29-Aug-18	Adult	2	123.0	3	2-Oct-19	NA	2-Oct-19	5-Oct-19	4998	Dead; Malnutrition/Disease
78	427	29-Aug-18	Adult	7	144.4	2.5	4-Jun-20	NA	NA	NA	7149	Unknown; collar failed
79	428	29-Aug-18	Adult	8	155.4	3	24-Jun-20	NA	NA	NA	7446	Dropped collar
80	429	29-Aug-18	Adult	3	121.9	2	24-Jun-20	NA	24-Jun-20	NA	7907	Dropped collar
81	430	13-Sep-18	4	5	154.8	3	9-Jul-20	NA	NA	NA	6620	Dropped collar
82	431	13-Sep-18	8	10	133.0	2	10-Feb-19	NA	10-Feb-19	2-Mar-19	1933	Dead; Predation (Coyote)
83	432	13-Sep-18	4	5	132.9	2	22-Mar-20	NA	NA	NA	7020	Unknown; collar failed
84	433	20-Sep-18	Adult	4	145.0 ³	3	11-Feb-20	NA	11-Feb-20	18-Mar-20	6329	Dead; Predation (Puma)
85	434	20-Sep-18	Adult	3	131.7	3	16-Jun-20	NA	NA	NA	7324	Unknown; collar failed
86	435	4-Oct-18	Adult	4	127.3	3	3-Jun-20	NA	3-Jun-20	5-Jun-20	7233	Dead; Predation (Coyote)

¹ Age at capture estimated from tooth wear and replacement.

² Age ranges are given in brackets in situations where aging reliability was considered low.

³ Weights estimated.

⁴ Rump body condition scores (rBCS) in 2015 measured at either base of tail or pelvic wing.

⁵ Date the collar became stationary based on mortality event recorded by the unit or by formation of a final large cluster of locations. Activation of mortality mode occurs when the collar is stationary for 4 h and does not necessarily confirm the death of an animal.

⁶ Number of GPS fixes refers to the period from capture to the last day of the reporting period or to the mortality date from collar, whichever comes first.

⁷ Collar satellite transmission failed. Alive signal from VHF beacon.

⁸ Animals recaptured and fitted with new GPS collars on 12 Sep 2017.

Table A3. Carcass remains found at mountain lion GPS clusters visited in the field on the Siskiyou project, Feb 2017-Feb 2020.

		1F	2F	3M	4M	5M	6M	7M	8F	9F	10M	12M	13F	14M	15M	All pumas
Number of clusters visited		257	20	247	95	131	27	97	203	120	4	76	149	38	52	1516
Clusters with confirmed carcasses		73	2	57	31	47	3	31	68	43	3	23	43	9	11	444
Deer carcasses with video cameras		25	0	16	8	9	1	12	10	11	0	4	3	6	0	105
Elk carcasses with video cameras		0	0	1	3	2	0	0	0	0	0	0	0	0	0	6
Deer																
	Adult female	16	0	12	7	5	1	10	23	9	0	1	4	0	1	89
	Adult male	10	1	8	5	10	0	6	8	6	0	2	7	3	0	66
	Adult unknown sex	10	0	3	2	2	0	4	7	6	0	6	9	0	1	50
	Yearling female	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2
	Yearling male	1	0	1	0	0	1	0	1	1	0	2	0	2	0	9
	Yearling unknown sex	3	0	0	1	1	0	1	0	0	0	0	0	0	0	6
	Fawn	21	0	12	6	5	0	3	14	15	1	4	13	4	3	101
	Unknown age/sex	11	0	4	4	4	0	1	7	2	0	2	7	0	2	44
	Total Deer	72	1	40	26	27	2	25	60	39	1	17	41	9	7	367

Elk																
	Adult female	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
	Yearling female	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
	Yearling male	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2
	Calf	0	0	3	1	6	0	0	0	0	0	0	0	0	0	10
	Unknown age/sex	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	Total Elk	0	0	3	5	10	0	18								
Feral horse																
	Adult/unkn. sex	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	Total Feral horse	0	0	0	0	1	0	1								
Pronghorn																
	Adult/unkn. sex	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Total Pronghorn	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Other mammals																
Badger	Adult/unkn. sex	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Beaver	Adult/unkn. sex	0	0	2	0	0	0	0	0	0	0	1	0	0	0	3
Black bear	Young of the Year	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

Bobcat	Adult/unkn. sex	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
California ground squirrel	Unknown age/sex	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Coyote	Adult male	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Coyote	Adult/unkn. sex	0	1	1	0	3	0	0	0	0	2	0	0	0	1	8
Deer mouse	Adult/unkn. sex	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Gray fox	Adult male	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Gray fox	Adult/unkn. sex	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Gray fox	Unknown age/sex	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
Jackrabbit	Unknown age/ sex	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
Muskrat	Adult/unkn. sex	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Porcupine	Unknown age/sex	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Skunk Unknown	Unknown age/sex	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Spotted skunk	Unknown age/sex	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Western grey squirrel	Unknown age/sex	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Unknown mammal	Unknown age/sex	0	0	2	0	0	0	1	2	1	0	0	0	0	0	6

	Total Other mammals	1	1	8	0	9	0	4	5	3	3	4	0	0	1	39
Livestock																
Cattle ¹	Yearling female	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2
	Total Cattle	0	0	0	1	1	0	2								
Birds																
American robin	Unknown age/sex	1	0	2	0	0	0	1	2	1	0	0	0	0	0	7
Canada goose	Unknown age/sex	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Grouse	Unknown age/sex	0	0	1	0	0	1	0	2	0	0	0	0	0	0	4
Magpie	Unknown age/sex	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Northern flicker	Unknown age/sex	1	0	3	0	0	0	1	1	1	0	0	1	0	0	8
Scrub jay	Unknown age/sex	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Stellar jay	Unknown age/sex	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3
Turkey	Unknown age/sex	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Turkey vulture	Unknown age/sex	0	0	1	0	0	0	0	1	0	0	1	0	0	0	3
Varied thrush	Unknown age/sex	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2

Woodpecker	Unknown age/sex	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Unknown bird	Unknown age/sex	0	0	4	1	3	0	0	6	4	0	2	3	0	2	25
	Total Birds	2	0	15	2	3	1	3	12	7	0	5	6	0	2	58

¹ Scavenging event